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FRANK MACE AND OLIVE HORNBROOK MACFARLAND

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OF THE  
California Academy of Sciences

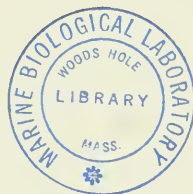
Volume VI

Studies of Opisthobranchiate Mollusks  
of the  
Pacific Coast of North America

BY

FRANK MACE MacFARLAND

Deceased, February 21, 1951



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## P R E F A C E

Dr. Frank Mace MacFarland's attainments as a professor of histology and related subjects at Stanford University are well known. Less well known, perhaps, were his interest in and his activity devoted to such institutions as the California Academy of Sciences and the original San Francisco Microscopical Society.

Always interested in microscopy and microdissection, he became a master, and much of his spare time for forty years was spent on detailed study of his favorite animals, the molluscan subclass Opisthobranchiata which includes the orders Tectibranchiata and Nudibranchiata. It was his intention to cover the classification of the major groups of this subclass with detailed studies of the anatomy of as many West-Coast species as possible. Unfortunately, he was not able to complete the work as planned. His "Order of Treatment," however, shows the classification he preferred. The groups which he did not study in detail and for which there was no completed manuscript in the Tectibranchiata are the Pteropoda and the species with external shells. For all of these there were notes and memoranda for use in preparing the final manuscript, consisting largely of references to literature and quotations from other authors' descriptions which are readily available.

Therefore, rather than try to incorporate this miscellaneous material into a creditable document, it has been decided to omit it in large part and confine the text to what is obviously Dr. MacFarland's original work, which in itself is monumental.

Through the years of painstaking work in this branch of zoology, Dr. MacFarland's helper was his devoted wife, Olive Hornbrook MacFarland. She prepared most of the final illustrations which accompany this report; the paintings are from the living animals and the drawings are from the sketches furnished by Dr. MacFarland. After his death she spent ten busy years preparing the manuscript in the form and order which only she could know would be as he wished. Some parts were marked by him "Final copy." Other parts, although they were finished descriptions of dissections, were not in the order he would have finally arranged them. That is, in working on the anatomy of an animal, convenience dictates the order in which particular parts are studied, but for publication Dr. MacFarland had a very definite order of arrangement, which he followed. This collation has been accomplished by Mrs. MacFarland.

It cannot be expected that a posthumously published work such as this can be entirely satisfactory. The mere fact that the author has not read either final manuscript or printed proofs must be considered in evaluating the text. No doubt it contains statements which the author would not have included in the final copy, and there must be omissions of material which he might have used. As an illustration, he had made partial generic revisions for many groups of species. In some cases these have the appearance to a non-specialist in Opisthobranchiata of being reasonably complete; in other cases it is obvious that he left merely a few random notes; to publish these would be a discredit to so meticulous a worker. If the editors had attempted corrections or additions which they considered to be beneficial, the student using the document might have been confused as to who is responsible for statements and conclusions. For this

reason, the entire text has been left in its original form, which in many places appears in note-like brevity. Any ambiguity is left to interpretation by succeeding workers.

During the fourteen years since the death of the author, there have been some nomenclatural changes in the Opisthobranchiata and there have been some species described by other workers as new from the west American localities. Some of these species may be ones which Dr. MacFarland also recognized as new and has described in the following pages. The present editors have decided that it would be presumptuous on their part to try to bring the work strictly up-to-date. It was Mrs. MacFarland's often expressed desire that the document should be made a true representation of her husband's work. Therefore, the editors have concluded that other students of this group of animals should offer any corrections or additions in separate contributions under their own names.

As for the descriptions, the dissections, and the drawings, there can be no question of responsibility.

Mrs. MacFarland spent the ten years after her husband's death in assembling and organizing his notes and manuscripts, a task of major proportion and one upon which no other individual could possibly have done a creditable job. She alone was familiar with his methods of operation, and from each of her finished drawings she was in a position to make countless decisions better than any other person could. In her tribute she has indicated some of the difficulties in connection with the orderly arrangement of a mass of data such as this document contains.

It should be noted at this point that Dr. MacFarland had a laboratory set up in his home especially for his opisthobranch work and for Mrs. MacFarland's illustrations. All of his notes, manuscripts, collections, and library were assembled there. The collections were rather extensive and in general well labelled and cared for. He did much of his anatomical work from thin sections and there are a great many of these. Some of the type material has been segregated from the bulk of the collection at the date of this writing, but there is still a great deal of checking to be done before some material can be identified. The collections are stored in the Department of Invertebrate Zoology of the California Academy of Sciences. The opisthobranch specimens in the collection of this department have been designated "The Frank Mace MacFarland Collection." The Department of Invertebrate Zoology has been designated the custodian of his manuscripts, notes, and huge bibliography pertaining to this group of animals. His library was left to Stanford University.

Throughout the preparation of the manuscript for final printing much assistance has been rendered by Mr. Allyn G. Smith of the Academy staff. His cooperation in this project extends back to long before Dr. MacFarland's death and continued thereafter through the remaining years of Mrs. MacFarland's participation.

Much detailed editing of the very difficult and technical manuscript was done by Mrs. Winifred S. O'Neill of the Academy staff. The printing of the plates as well as of the text was done by the firm of H. S. Crocker Co., Inc., of San Francisco.

G DALLAS HANNA, *Chairman*  
Committee for Preparation of the  
MacFarland Manuscript



## MEMORIAL

When my husband, Frank Mace MacFarland, was stricken on February 21, 1951, he had been engaged in intensive work on the manuscript of a monograph of the Opisthobranchiata of western North America. This had been a favorite subject of research for many years and it was expected that at least two more years would be required to complete the task. It was planned to treat all of the species of the group which had been reported from the area, some in more detail than others. Also it was contemplated that there would be adequate diagnoses of genera and higher groups. A definite order of treatment had been worked out and some portions of the manuscript were marked "Final" by the author. However, even these were the first draft. Many of the remaining data were filed in notebooks under proper headings, but not necessarily in the order of treatment of anatomical descriptions which he had adopted.

After careful consideration and consultation with some of his colleagues, it was decided that I should endeavor to organize the manuscript so that the many years of labor by the author would not be lost.

It was soon realized that the original title of the work should be changed from the one which had been intended to the one which appears herein. While it might have been possible with the help of others to complete the task somewhat as the author had contemplated, the many additions would not have been his work. Therefore, it seemed best to include all of the original work of the author which could be done without additions or modifications. It is hoped that those who read and use this report will bear these facts in mind.

A few words as to his methods of working should add to the confidence which can be placed in the statements in the text. He was meticulous in all of his dissections and wrote his notes as he proceeded. Sketches were made of various portions of the anatomy and these were passed to me to make the finished drawings. These were finally all checked by the author. The same care was used when reconstructions were made from thin sections.

It was with greatest enthusiasm that we worked together on the beaches as well as in the laboratory.

Representatives of living animals were kept until adequate color sketches could be made, after which they were anesthetized and preserved for anatomical work. The zeal in collecting, the accuracy in study, the scholarly approach, and the ever-present enthusiasm of the author, were my inspiration for fifty years. A placid pool just catching the slanting rays of the rising sun over the Gabilan Range; the soft dripping from the fringe of *Ulva* above the crystal depths just at the turn of the tide; a bit of color

crawling on a bed of green almost out of sight — yes, it is a beautiful aeolid. To capture its form and colors, to study each detail of this mite of life, to represent its intricate anatomy, all this and more filled the years with pleasure.

My greatest appreciation is offered to those in the Departments of Anatomy and Zoology of Stanford University for much help and cooperation. I could not have proceeded with the undertaking without the support and encouragement of Drs. Charles Danforth, Rolf Bolin, and Walter K. Fisher. To Professor Nils Odhner I give cordial thanks for invaluable help and decisive suggestions in many letters received through the years. Some of the staff of the California Academy of Sciences, where my husband was President and Director for a number of years, became familiar with his work and his wishes as to format of final publication.

OLIVE HORNBrook MacFarland

## FRANK MACE MACFARLAND

1869-1951

Frank Mace MacFarland was one of the kindest and friendliest of men. He radiated cheerfulness and good will. People were always glad to see him come and sorry when he left. The warmth and good humor of his personality carried over into his correspondence, so that even a short note from him on a business matter gave the recipient a chuckle and left one feeling happier for having read it. He lived almost a dozen years past the traditional three score years and ten, yet those who knew him felt that his life was too short and his death untimely. It is seldom that the passing of any individual brings to so many such a definite sense of personal bereavement.

The reason people liked him was that he liked them. He had an extraordinary capacity for friendship. His friendliness was not a superficial thing, no mere matter of politeness or graciousness, although he was unfailingly polite and warmly gracious, in a manner that is almost forgotten in the haste and bustle of modern life. When he inquired what you were doing and how you were getting along with it, you felt that he was really interested — and he was. Moreover, he remembered what you told him, and three weeks or three years later he could take up the conversation right where it had been left off. His interest in people was genuine, and they responded to it with appreciation and affection.

He was an extraordinary raconteur. He knew how to tell a story and get the most out of it. Every time you went to lunch with him, or sat down for half-an-hour of quiet conversation, you would get two or three good stories, of his early life in Illinois, or of his undergraduate days at De Pauw, or his graduate work in Germany, or his experiences as a young teacher at Olivet College and then at Stanford, where he was appointed an instructor in 1892 (a year after the University opened) and where he remained the rest of his life. Having been in Europe in the latter years of the nineteenth century, he was acquainted with most of the great European zoologists of that period; and with his marvelous memory he could give "personal glimpses" that would make them come alive — Oscar and Richard Hertwig, Anton Dohrn, Rudolph Leukhart, Karl Gegenbauer, and others. His anecdotes were entertaining, brief, and to the point. If anybody had had the good sense to write them down and assemble them into a book — and there were plenty to fill a book — it would undoubtedly have been a best seller.

On the more serious side — and wholly apart from his scientific accomplishments, of which we have not yet begun to speak — he was a lifelong student of human civilization. Hardly a subject of conversation could be brought up to which he could

not make an informed contribution. He had a wide knowledge of history, and an intimate acquaintance with the world's best literature. He was especially fond of poetry and would, if the occasion were right, quote long passages from memory, not only of English verse, but if he were in a multilingual company, of German and Italian as well. He had a good knowledge of French and the classical languages also, but one discovered this almost by accident. He was clearly partial toward the German and Italian languages and literature. I think the explanation is that his happiest days abroad were his student days in Germany, and the periods he spent at the Naples Zoological Station. For those days he had an unforgettable nostalgia, and with the respective languages he felt comfortable and at home.

Dr. MacFarland's scientific activity covered a period of more than sixty years, and they were years of unflagging zeal. He celebrated his eightieth birthday by getting up before daylight to get down to a rocky beach at dawn and look for nudibranchs in tide-pools at extreme low tide. From one end of his life to the other, he was always interested in what he was doing, and was always doing something interesting.

He was born in Centralia, Illinois, June 10, 1869, the son of Dr. Parker M. MacFarland and Sarah Mace MacFarland. He attended De Pauw University, where he graduated in 1889. Almost immediately he was appointed "professor of biology and geology" in Olivet College in Michigan. He was at that time twenty years old.

While his primary interest, then as always, was biology, he took his duties as professor of geology quite seriously. When he got to the subject of geysers, he decided he could best demonstrate with a model. So, with what glassware and tubing he could assemble, he made a geyser. He explained to the students the principle involved, then applied some heat in the proper place. His geyser not only worked, it far exceeded his hopes. As the steam pressure rose, everybody watched with breathless interest. Suddenly the critical point was reached — the geyser functioned: a column of water squirted up to the ceiling, spread out then came down again, giving both professor and students an unexpected shower bath. Fortunately no damage was done except to classroom decorum; but it is a safe guess that every student in that class learned and remembered how a geyser works. This anecdote, which Dr. MacFarland once recounted to me with much amusement, really affords a great deal of insight into his genius as a teacher.

In 1892 Frank MacFarland was called to Stanford as instructor in histology — one of the young men that David Starr Jordan was gathering about himself to make that new university great. While teaching there, he took a graduate degree (A.M., Stanford, 1893) and subsequently decided to go to Germany for his doctorate, something that was almost a standard practice at that time. He studied at the universities of Würzburg, and Zürich, obtaining his Ph.D. at Würzburg in 1896. During that period abroad he became acquainted with the leading figures in zoology in Europe in the closing years of the nineteenth century, and was able in subsequent years to transmit to his students the high ideals and meticulous craftsmanship of the great men who represented European science at its best.

While visiting in Indiana on his way to Germany for graduate study, Frank MacFarland met Olive Knowles Hornbrook, a young woman who was to become the companion of his life. They were married in 1902, and for nearly fifty years they worked together. She studied zoology at Stanford the better to share her husband's interests, and – herself a gifted artist – Olive MacFarland learned to make scientific drawings as meticulously accurate as they were beautiful. On his part, he took great pride in his wife's accomplishments in this specialized field, and never missed an occasion to compliment her.

Returning to Stanford after his sojourn in Europe, Dr. MacFarland advanced through the ranks of assistant and associate professor to become professor of histology in 1909, which post he held with distinction for a quarter of a century until his retirement in 1934. He was active in establishing the Hopkins Marine Station at Pacific Grove, and served as its co-director from 1915 to 1917. He served for many years as chairman of the committee on admissions of the Stanford Medical School, a difficult and highly responsible assignment offering little reward save a sense of duty well done. He served a great and growing university in many selfless ways. But his finest service was that of imparting to his students, year after year, his own unswerving ideals of scientific scholarship and of the social responsibility of the scientist.

Second only to his service to Stanford University was his service to the California Academy of Sciences, an organization with which he was closely identified, especially during the last twenty-five years of his life. He became Corresponding Secretary of the Academy in 1926, First Vice-President in 1932, and President in 1934, to which office he was re-elected for successive terms until 1946, when he declined the nomination in order to devote his time more fully to his scientific work.

In addition to his duties as president, Dr. MacFarland served from 1934 to 1939 as acting director of the Academy's Museum and Steinhart Aquarium. This was a period of severe financial stress stemming from the "depression years." Membership had declined and income from endowment was seriously curtailed. There was one dark year when the Academy had to borrow money at the bank in order to meet its payroll. In this difficult period, Dr. MacFarland's Scotch thrift and his unfailing optimism and good humor provided just the right combination. He deserved far greater credit than he received for successfully guiding the Academy through a major crisis.

My own acquaintance with Dr. MacFarland covered only the later years of his long and busy life, but they were years of a heart-warming friendship. When I was appointed to the directorship of the Academy in 1938, he surrendered the reins of that office to me with obvious relief and immediately went off on a collecting trip. I did not see him again for a month. When he came back, he was his usual cheerful self, and as President of the Academy he presided at the monthly meetings with dignity and grace; but, although he had been acting director for three years, he never tried to influence my decisions, never looked over my shoulder to see how I was doing. When I sought his advice, as I frequently did, he was guide, counselor, and friend; but he did not

offer a suggestion unless I asked it. I have never known anyone who, while retaining an administrative post, could retire from an executive position so immediately and gracefully and turn the reins so completely over to his successor.

After his retirement from the presidency, he became a kind of elder statesman, whose advice was sought on many important occasions. He was keenly interested in the building program, and never came in to the Academy without studying the plans and watching the way they became translated into reality. To the end of his career he retained a boyish enthusiasm, and he was interested and excited to see things moving forward.

When, after an absence of some weeks due to illness, he came to the Academy on the morning of what proved to be the last day of his life, it was characteristic of him that the first thing he did was to go into the new building. He looked at the auditorium, the planetarium, the new exhibit halls, and the Foucault pendulum, and exchanged cheery words with the preparators who were hurrying to install the last exhibits before the building was opened to the public. He then repaired to the Library and began looking up references relating to his beloved nudibranchs.

Later in the day, while walking across the courtyard with his old friend Dr. Earle G. Linsley to attend the 97th Annual Meeting of the Academy, he collapsed and died at the entrance of the new building he had helped to plan. But he had already been through it and seen it. It was symbolic of his whole life that he hadn't missed a thing. Death took him as it were in mid-stride, busy at his work, happy in the companionship of friends, and standing on the threshold of an institution he had helped to build to its present greatness.

ROBERT C. MILLER



## CONTENTS

	PAGE
FRONTISPIECE . . . . .	IV
PREFACE. . . . .	VII
MEMORIAL . . . . .	IX
FRANK MACE MacFARLAND, 1869-1951. . . . .	XI
Class GASTROPODA. . . . .	1
Subclass OPISTHOBRANCHIATA . . . . .	1
Order TECTIBRANCHIATA. . . . .	1
Suborder CEPHALASPIDEA. . . . .	1
Superfamily PHILINACEA . . . . .	1
Family PHILINIDAE . . . . .	1
Family GASTROPTERIDAE . . . . .	2
Family AGLAJIDAE . . . . .	6
Suborder ANASPIDEA . . . . .	12
Family APLYSIIDAE. . . . .	12
Order SACOGLOSSA . . . . .	38
Family STILIGERIDAE. . . . .	38
Family ELYSIIDAE . . . . .	50
Order ACOELA . . . . .	56
Suborder NOTASPIDEA . . . . .	56
Family UMBRACULIDAE . . . . .	56
Family PLEUROBRANCHIDAE . . . . .	69



	PAGE
Suborder NUDIBRANCHIATA . . . . .	101
Superfamily DORIDACEA . . . . .	101
Family POLYCEERIDAE . . . . .	101
Family CORAMBIDAE . . . . .	129
Family DORIDIDAE . . . . .	140
Superfamily ARMINACEA . . . . .	197
Family ARMINIDAE . . . . .	197
Superfamily DENDRONOTACEA . . . . .	206
Family DUVAUCELIIDAE . . . . .	206
Family HANCOCKIIDAE . . . . .	243
Family DENDRONOTIDAE . . . . .	254
Family FIMBRIIDAE [TETHYIDAE] . . . . .	280
Family DOTONIDAE . . . . .	287
Superfamily AEOLIDIACEA . . . . .	295
Family DIRONIDAE . . . . .	295
Family ZEPHYRINIDAE . . . . .	302
Family FLABELLINIDAE . . . . .	308
Family CUTHONIDAE . . . . .	326
Family FIONIDAE . . . . .	354
Family AEOLIDIIDAE . . . . .	358
BIBLIOGRAPHY . . . . .	379
EXPLANATION OF PLATES . . . . .	394
INDEX . . . . .	537
PLATES . . . . .	1-72

STUDIES OF OPISTHOBRANCHIATE MOLLUSKS

OF THE

PACIFIC COAST

OF

NORTH AMERICA

BY

FRANK MACE MACFARLAND



PHYLUM MOLLUSCA  
Class GASTROPODA  
Subclass OPISTHOBRANCHIATA  
Order TECTIBRANCHIATA  
Suborder CEPHALASPIDEA  
Superfamily PHILINACEA  
Family PHILINIDAE  
Subfamily PHILININAE

Genus **Philine** ASCANIUS

*Philine* ASCANIUS. 1772. Kongl. Vet. Akad. Handl. Stockholm, vol. 33, p. 331. Genotype, *Philine quadripartita* Ascanius (= *Bulla aperta* Linnaeus, 1767).

**Philine bakeri** Dall

Plate 7, figures 15-20

*Philine bakeri* DALL, 1920. Proc. U.S. Nat. Mus., vol. 56, p. 300.

"Shell minute, translucent, of two or more whorls, enfolded, except the subglobular nucleus by the last whorl; apex blunt; last whorl narrow, obliquely expanded in front; sculpture of numerous fine incised punctate spiral lines with wider interspaces; axis gyrate, pervious; aperture as long as the shell, narrow behind with a very slight sulcus, but widely expanded in front; outer lip thin, sharp, straight, inner lip hardly glazed; height, 2; diameter, 1.25 mm."

Type, U. S. National Museum, No. 225194.

Type locality, off South Coronado Island, near San Diego, California.

Five specimens were dredged off the pier at La Jolla, California, August 23, 1915, and it has been taken in a submarine canyon at the depth of about 100 fathoms.

*Body form.* Broad, flattened, but little arched. The head shield is rectangular, its anterior length 25 mm., breadth 22 mm., slightly less at the posterior end. Anterior end bluntly rounded, the mid-line with a shallow notch, the posterior almost square, overlapping the mantle surface.

The mantle lobe of the larger specimen is 23.2 mm. wide at the anterior end, 16.4 mm. at the posterior rounded end.

*Foot.* Bluntly elliptical, 35 mm. long, 25 mm. wide, at the anterior end notched in the median line, the posterior margin broadly rounded, the sides curved upward as

very low parapodia and terminating against the sides of the cephalic shield but not overlapping it. In some specimens, the parapodia are not evident, the broad margin of the foot representing them.

*Rhinophores.* No traces of these were present.

*Mantle margin.* The posterior end of the mantle margin is horizontally divided into two laminae, the upper short and entire, the lower divided into two lobes meeting in the mid-line and forming the floor of a pocket-like passage leading into the caecal cavity which contains the gill and the reproductive and anal openings. The floor of the cavity is formed by the dorsal foot surface. On the right side is the gill attachment and in front of it the genital papilla with its central opening. From it the spermatic furrow extends forward to the opening of the penial sac (preputium) at the side of the head.

*Color.* The living animals are almost white or a pale cream. In alcohol the smaller specimen has become a pale brown. The surface of the larger specimen is quite smooth, that of the smaller one has a roughened texture, in life a crusting of white over the surface.

## Family GASTROPTERIDAE

### Genus *Gastropteron* KOSSE

*Gastropteron* KOSSE, 1813. *Dissertatio de Pteropodium ordine et novo ipsius genere*, Halle, pp. 10-16.

### *Gastropteron pacificum* Bergh

Plate 1, figures 1-5; plate 7, figures 1-10

*Gastropteron pacificum* BERGH, 1894. *Bull. Mus. Comp. Zool.*, vol. 25, no. 10, pp. 201-205, pl. 12, figs. 1, 2.

A tectibranch was dredged on August 1, 1894, from the wharf at Monterey, California, by Horace Campbell and T. M. Williams, students from the Marine Station. The animal was active, moving with gliding motion around a 12 cm. dish. It measured 33 mm. in length, 13 mm. in width, 9 mm. in height. On August 3 a second specimen was dredged from the wharf in about 5-10 fathoms, hard sand bottom. The dredge was filled with squid eggs, brown algae, and numerous aeolids. This smaller specimen was 14 mm. long, 6 mm. wide, 7.5 mm. high.

*Form.* Elongate, high, rather narrow and compressed.

*Parapodia.* Flat, rounded, margin folded up around the sides to the median line of the back, meeting, and slightly separating a third of the distance from the tail, forming a rounded aperture; marked off laterally by a shallow longitudinal groove.

*Foot.* Elongate triangular, the margin rounded, notched below the mouth. A median caudal gland at the posterior end.



*Head.* Flattened above, rounded downward in front and sides, its dorsal surface modified into a thick cephalic shield with distinct lateral margins, produced and inrolled posteriorly into a dorsally directed tube.

*Mandibles* (pl. 7, figs. 9, 10). As seen through the bulb lining after potassium hydroxide treatment, these are dark brown in color; the general cuticular lining of the anterior bulb is quite thin and a very pale yellow.

The mandibles are situated on the upper side of the tube slightly less than vertical in position, the broader upper ends slightly posterior to the lower more pointed ends. The upper ends are close together on either side of the dorsal median line of the oval tube. The mandibles occupy about half of the side of the tube. The following measurements for the two specimens, respectively, are from sections.

*Mandibles.* Somewhat triangular (not entirely flattened out). (Pl. 7, fig. 10.)

0.36 mm. long, 0.09 mm. wide

0.285 mm. long, 0.075 mm. wide

*Rodlets.* (Pl. 7, fig. 9.)

0.072 × 0.006 mm.

0.06 × 0.006 mm.

*Radula.* Stained in bismarck brown; 1.4 mm. long; straight and colorless after potassium hydroxide treatment (pl. 7, figs. 5-8); moderately grooved lengthwise; 18 rows of teeth plus two immature rows; first lateral large, border denticulate; denticles irregular in size, 12-20 (pl. 7, figs. 5, 6). Five and six external laterals hooked, slender, compressed.

*Color.* (Pl. 1, fig. 1.) Ground color in life pale yellow ochre with tinge of red, everywhere mottled with clusters of small red spots slightly purplish; mantle cavity not pigmented; base of gill yellowish. In alcohol, a clear yellow ground color with numerous more or less grouped, or closely set points of red on head shield, parapodia, and foot, closer together on under side and tip of head shield; hinder body gray with scattered red points in clusters; gill pale.

*Dimensions.*

Living specimens taken in 1894, Monterey Bay:

Larger, 33 mm. long, 13 mm. wide, 9 mm. high;

Smaller, 14 mm. long, 6 mm. wide, 7.5 mm. high.

*Alcoholic flattened specimen:*

Diameter between tips of parapodia, 10.2 mm.

Anterior-posterior width of parapodia, 7.5 mm.

Height of flattened parapodia from foot edge to margin, 3.9 mm.

Length over all, 6.4 mm.

Length of foot, 5.8 mm.

Width of foot, 3.4 mm.

Maximum height of body, 4.2 mm.

*MacGinitie specimen*: Balboa Beach, 33 fathoms.

Length of foot, 5.6 mm.

Maximum width of foot, 2.0 mm.

Length over all, 5.9 mm.

Length of parapodia, 6.3 mm.

*Bergh specimen, 1893*:

Length of parapodia, 7.5 mm.

Width of whole animal, parapodia outspread, 12 mm.

Height, 5.5 mm.

*Habitat.* The species was originally described by Bergh (1894) from 14 specimens dredged off Unalaska, Aleutian Islands, Alaska, in August, 1874, 9-15 fathoms, stony bottom. Campbell and Williams dredged it in Monterey Bay, 5-10 fathoms, sandy bottom, August 1, 3, 1894. The species has also been taken off San Francisco and along the west coast of Central America from the Gulf of California to the Galapagos Islands by the U.S.S. *Albatross* in 1881. Four small specimens collected in Newport Bay in 1933 had the bright red color retained but no band pattern was recognizable as shown in the Monterey specimen, which was illustrated. One large and three small specimens were dredged in May, 1933, in 33 fathoms in Newport Bay, California, by George MacGinitie.

The *ductus anonymous*, described by Bergh (1893, pl. 16, fig. 25, p. 301) for *Gastropteron meckeli*, does not occur here, although the close attachment of the hermaphroditic duct to the surface of the adnexed glands might readily suggest the possibility of such a structure.

Bergh was unable to make out the details of this duct system in his material of *Gastropteron pacificum*. This loop of the hermaphroditic duct is clearly figured by Vayssi re (1880, pl. 5, fig. 43). While entirely closely attached to the glans complex, the true relationship may be made out in *Gastropteron pacificum* and confirms Vayssi re's description for *Gastropteron meckeli*.

*Reproductive system* (pl. 7, figs. 1-4). The *hermaphroditic duct* upon leaving the hermaphroditic gland is first straight and slender for about 0.45 mm., then doubles in thickness and is closely coiled upon itself for about 0.5 mm. in a segment which may correspond to the first ampulla described by Bergh for *G. rubrum*. This is followed by a sinuous segment approximately 0.75 mm. in length, which becomes closely attached to the dorsal surface of the mucous gland upon which it forms several loops on passing to the sexual cloaca.

It opens into the sexual cloaca (*vestibulum genital*) a pear-shaped dilatation communicating with the exterior at the posterior end of the seminal groove and receives the duct of the nidamental-albumen glands and the short duct of the spermatheca. This is a thin-walled, somewhat pyriform sac, 0.7 mm. in greatest diameter, opening into the sexual cloaca at its proximal end by a short duct.

The nidamental gland mass is small, somewhat oval in outline and dorso-ventrally flattened. It is divided into three lobes of nearly equal size and communicates

with the cloaca by a short duct. The distal lobe may be due to a breaking across the body of the gland. The distal end is divided by a deep groove which can be traced on both faces of the gland as dissected. The albumen gland has probably crumbled in dissection and cannot be made out clearly.

The hermaphroditic duct swells into a spindle-shaped ampulla between the vestibulum and the adnexed gland complex, narrows at *b*, and forms a loop, *c*, closely adherent to the periphery of the nidamental gland around which it passes in a sinuous course to the proximal portion of the nidamental-albumen gland complex into which it opens.

The *prostate gland* is a long tubular structure closely coiled into a compact, slightly compressed, conical mass about 1.8 mm. long by 0.8 mm. in greatest diameter. (Pl. 7, fig. 2.) Its distal end passes into the proximal end of the preputial sac containing the glans penis. In the dissection the relations are not clear. The sac is lined with low columnar epithelium. Toward the distal end there appears to be a jagged margin bearing a series of flattened conical papillae of epithelium, the largest of which measures about 0.06 mm. in diameter and 0.095 mm. high. This seems to form a margin, but is not at the outer opening of the preputium. The narrowed duct of the prostate passes into the base of this but the glans is not certain, being apparently damaged. (Pl. 7, fig. 3.)

After mounting in clarite the glans becomes visible as a slender conical organ attached close to the distal end of the duct of the prostate gland; the relationship is not clear. It is 0.24 mm. long by 0.036 mm. in basal maximum diameter.

The *preputial sac* opens by a relatively narrow canal into the anterior end of the seminal groove, the dorsal ridge of the latter being prolonged inward at the mouth of the opening and passing down the canal terminating at its inner end. Parallel to it are three low papillose folds of the canal lining which end before reaching the main cavity, as seen with the highest power of a Zeiss binocular dissecting microscope. At its inner end the fold shows a bifurcation, each branch dying away in the dorsal preputial wall as the main sac is reached. (Pl. 7, fig. 4.)

The proximal part of the preputium appears as a roomy sac of somewhat oval shape, the distal end of the preputium disappearing in its dorsal wall leaving a considerable dilatation proximal of its opening.

Opening the sac by removing the whole thin ventral wall, a peculiar calyciform structure attached to the dorsal wall is revealed. It consists of a plate-like collar attached obliquely to the wall at the base and terminating in an undulating margin bearing a series of small pointed papillae in tooth-like arrangement (pl. 7, fig. 3), the whole forming a revolute collar surrounding the opening of the prostate-gland duct.

Bergh (1893, p. 306, pl. 17, figs. 24-26) described and figured the glans penis as short, conical at the base of the preputium in *G. pacificum*. Despite repeated and careful dissections I am unable to confirm his statements. His figures show the glans as seen through the wall of the preputium, probably in a glycerine preparation, and he does not seem to have observed any such structure as here described.

*Shell* (pl. 1, fig. 5).

*Visceral mass* is globular, slightly elongate, free from the foot and parapodia far forward to just below the anal opening.

*Anus* mid-lateral, immediately behind the gill; the opening at the summit of a low cylindrical papilla behind the middle of the gill and just below the end of the narrow pallial margin.

*Reproductive opening* in the lower side of the head on the right. From it a groove runs backward and upward toward the base of the gill.

*Gill* on the right side lying in the shallow mantle cavity, its basal axis 2.5 mm. long; eleven simple pinnate branches attached along a slightly curved stalk attached at a point nearest back, inclined downward and backward. Twelve plates in the gill, each bearing numerous platelets laterally. Inner margin of a plate is continuous with the basal plate except at the posterior margin where each ends in a pointed tip. The front margin of the gill attached to the prominent rachis. Immediately in front of the ridge, formed by the rachis, is the termination of the genital furrow, the flap-like lower margin termination being partly concealed by the ridge. The first lamellae are more prominent than the remainder. About half of the gill is free from the body wall. (Pl. 1, figs. 2, 3.)

*Mantle margin* above the gill is very narrow, leaving the gill exposed. The posterior margin, at the angle, is rounded and not at all produced into a flagellum as in *G. meckeli*.

## Family AGLAJIDAE

### Genus *Aglaja* RENIER

*Aglaja* RENIER. 1804. Prospetto della Classe dei Vermi, Padova, p. 16. Genotype, *Aglaja tricolorata* Renier.

### *Aglaja diomedea* (Bergh)

Plate 2, figure 4; plate 6, figure 8; plate 7, figures 11-14

*Doridium diomedea* BERGH. 1894. Bull. Mus. Comp. Zool., Harvard, vol. 25, no. 10, pp. 211-212, pl. 11, fig. 1. Alaska.

*Aglaja diomedea* (Bergh), PILSBRY. 1895. Man. Conch., vol. 16, pp. 52-53, pl. 1, fig. 14; pl. 15, fig. 95.

*Body* oblong, cylindrical, the foot rounded laterally upward into the low, fleshy parapodia, the foot extending about three-fourths to four-fifths total length, being overlapped posteriorly by the remainder of the body.

*Head shield* slightly shorter than body shield, its margin forming a free rim all around, slightly overlapping the posterior shield, its surface smooth, a narrow well de-

finned but shallow, median, longitudinal groove appearing in most of the specimens. Posterior shield or mantle bounded laterally and in front by a deep groove, and behind prolonged as two, equal, blunt, squarish lobes covering the gill and the posterior end of the body.

*Color* in preserved condition brownish-black except in the grooves between the shields and the parapodia, which are pale yellow. In a colored sketch from life made by Dr. H. J. Snook, the black dorsal surface has a strong bluish sheen, most pronounced on the cephalic shield, the outer faces of the parapodia and the periphery of the body shield. In Bergh's description the color is given as: "Head shield dark brown, almost black, the body shield dirty reddish brown, both finely dotted with yellow; the sides of the body and the groove between the shields bluish gray; the upper side of the parapodia and of the tail, gray, the small gill yellow. The color is said to be nearly black in life." Hind wings of mantle contracted, apparently not strongly developed above, separate, rather rigid, with rounded posterior end, the left not prolonged into a flagellum.

*Shell* of peculiar shape, in the largest specimen measuring 5 mm. in length by 3.4 mm. in width through the spire, entirely calcified, thinner at the anterior margin and more yellowish, otherwise chalk white. Spire small, not free, the ventro-anteriorly directed process large, the hollow in it adjacent to the spire, rather deep. (Pl. 6, fig. 8.)

*Pharyngeal bulb* very large, muscular, containing no trace of mandibles or radula.

*Distribution.* Kodiak Island (St. Paul); Bering Sea; Yukon Harbor, Shumagin Islands, Alaska, 6-10 fms., (Dall, Aug., 1874); False Bay, San Juan Island, Puget Sound, mud flats, H. J. Snook, July, 1921; Puget Sound, M. H. Hatch, Aug., 1940, (pl. 6, fig. 8, photo); Elkhorn Slough, Monterey Bay; Tomales Bay, California (G. E. MacGinitie), 1930.

The best information concerning the mode of life of this species is that given by Professor G. E. MacGinitie (1935, p. 736) in his excellent ecological study of Elkhorn Slough, Monterey Bay, California. The animal is listed as *Philine* sp., an error, because of a tentative identification by the present writer without the necessary dissection.

On September 2, 1921, six specimens were received from Dr. Myrtle E. Johnson: a collection made by H. J. Snook, July, 1921, from False Bay, a shallow bay on the west side of San Juan Island, Puget Sound. A colored figure was made by him with a label "Like *Navanax* in habitat of the mud-flats of False Bay." His first impression was that the specimens were *Philine*. Shells were isolated from this collection and were found to be practically identical with those of *Aglaja diomedea* (Bergh). The Snook shell is figured on plate 7, figures 11, 12.

On August 11, 1950, six specimens were received from Minnesota Reef and Argyle Lagoon, San Juan Island, collected by Emery E. Swan, on July 29, 1950. The largest was 16.3 mm. in length, the smallest 7.2 mm. Color, deep brown sprinkled with pale yellow spots.

Seven specimens were collected in Drakes Bay, California, by Jane Westfall of Mills College, on November 11, 1950. The largest was 10.3 mm. long, 4.1 mm. wide, 3.4 mm. high. The color was dark brown, closely sprinkled with small light spots. Plate 7, figures 13, 14 were drawn from Drakes Bay specimen.

Another specimen from 5 fathoms in Drakes Bay was received on August 24, 1950, alive, from M. Woodbridge Williams of Inverness. The animal was kept alive and in good condition for five days. The specimen matched the colored figure (pl. 2, fig. 4) of the original specimen taken from Monterey Bay in 1894. The following paragraphs of descriptive characters are based upon the Williams specimen.

*Head.* The cephalic shield is 16 mm. in length, rounded behind, the margin entire. The anterior end dilates laterally as it curves downward over the head region forming a slight prominence elevated above the general level. The mouth is concealed beneath this hood.

*Body shield.* This is 17 mm. in length, by 10 mm. in width; the posterior end being prolonged into the caudal lobes.

The caudal lobes also are marked with many golden yellow spots, the flagellum being entirely covered. The inner surfaces of the parapodia are a madder brown with scattered light spots; the color is pale below, deepening as the outer margins are reached, gradually merging with the ground color.

*Dimensions.* Living animal partly contracted and quiet.

Length of foot to hinder mantle processes	21 mm.
Width, maximum	9 mm.
Height, maximum	7 mm.
Head shield, length	16 mm.
Mantle shield, length	17 mm.
Hinder mantle process, right	1.6 mm.
Hinder mantle process, left	3.0 mm.

*Foot.* The anterior edge thin, the angles are produced into short, bluntly rounded processes, quite sensitive to the touch and acting as tactile organs. A faintly defined band across the head, from angle to angle, is formed by an increase in the fine pigment spots showing a light zone, the body color being reduced by the network. Laterally the foot passes up into the sides of the body without sharp boundary. There is a deep space below the anterior end of the cephalic lobe and the foot.

*Caudal lobes.* These lobes project from the mantle's end; the right one is short, triangular, and edged irregularly with pale yellow; the inner surface is brown madder. Its light margin is produced dorsally into a narrow band of small light dots merging with the general color. The left lobe, triangular, of about the same size as the right one but is prolonged far beyond it as a delicate filament (flagellum). This is translucent, slowly motile, usually coated with mucus. The filament is 2.5 to 3 mm. in length, extending beyond the posterior foot margin.



*Parapodia.* These are thick and pass imperceptibly into the sides of the foot without definite boundaries: the edges are quite thin and held close to the sides of the body, as the upper margins are reached.

### Genus *Navanax* PILSBRY

*Navanax* PILSBRY, 1895. Nautilus, vol. 8, p. 131. Genotype, *Strategus inermis* Cooper. [Author of the genus not mentioned, but obviously it is Pilsbry.]

### *Navanax inermis* (Cooper)

Plate 2, figures 1-3: plate 6, figures 10, 11; plate 7, figures 21-23

*Strategus inermis* COOPER, 1862. Proc. Calif. Acad. Nat. Sci., vol. 2, pp. 202-203, San Diego Bay, California.

*Navanax inermis* (Cooper), PILSBRY, 1895. Man. of Conch., vol. 16, pp. 57-58, pl. 15, figs. 89-93.

DALL, 1921. Bull. U.S. Nat. Mus., no. 112, p. 64. Catalina Island to San Diego, California.

*Head shield* 50 mm. long, almost equal to the body shield. The anterior margin blunt, slightly thickened, straight, its outer angles produced into short, rolled tentacles; deeply grooved on the upper anterior surface. Labial palps are on the inner side, lateral to the mouth. These, as well as the anterior outer margins of the rolled tentacles, are covered with short, closely set, white, blunt, hair-like processes which are very sensitive and retract quickly when stimulated. (Pl. 7, figs. 21, 22.) The median anterior margin of the head is notched into a groove, dying away upon the upper surface. On the crest of parallel ridges are found the eyes, each in the center of a white spot. In a stupified specimen, the everted mouth opening shows seven or eight low, blunt papillae: these are extended and show clearly in the swallowing act. They are either gustatory, tactile, or both. (Pl. 7, fig. 23.)

The *body shield* is elongate and elliptical, its margins narrow. The posterior half projects freely beyond the body and is prolonged into two nearly equal triangular lobes: the left, 30 mm. long frequently extends beyond the right, the shorter, about 20 mm. (Pl. 2, figs. 1, 3.)

*Gill* bipinnate, brown, thickly sprinkled with minute white spots; 13 anterior divisions, 11 posterior.

*Color.* (Pl. 2, figs. 1, 2, 3.) General body color is velvety, dense, dark brown; the body and parapodia ornamented everywhere with oblong spots of pale yellow. A wide range is found in the general brown color from darkest brown, van dyke brown

plus indian red, to light brown, ochre in tone. Over all is a sheen of blue-violet, brilliant in reflected light, deepest in the shadows and on the head and tail parts. Very dark brown specimens with this sheen are sometimes described as black. The effect of the violet is difficult to represent with water colors.

The inner surface of the parapodia is light brown, thickly dotted with fine whitish points. A slight ridge follows within the curvature of the extreme outer anterior margin. This ridge is covered by a line of yellow spots, found to be a constant marking. (Pl. 2, fig. 1.)

The outer surface of the parapodia (pl. 2, figs. 1, 3) is very closely covered with short yellow lines, running lengthwise, intermingled with rounded spots. Ventrally these narrow spots widen into oval lines and may become a continuous band in the central region, interrupted, at the ends, by a series of spots or broken lines.

The outer edges of the parapodia, edges of the tail lobes, the posterior margin of the cephalic shield, and the outer margins of the head are marked by a continuous line of orange-yellow. Everywhere within this line is found a row of elongated cerulean blue spots forming almost a continuous line. Scattered spots occur on the head and tail lobes.

The dorsal surfaces of the inrolled tentacles of the head margin are conspicuously marked by a wide, elongated line of light yellow.

Midway of the posterior shield, there is found, on each side, a triangular group of fine yellow lines, spreading out from a point which is hidden by the parapodial margins. Similarly shaped groups of fine yellow lines are found on the head shield, one-third posterior of the margin. These are shown on plate 2, figure 3 and plate 6, figure 10. In plate 2, figure 1 they are concealed by the parapodia held close to the body. These distinctive groups were constant on many specimens studied.

The posterior margin of the cephalic shield is rounded and overlaps the body shield. This margin is edged by very narrow lines of yellow. The surface of the shield is marked with broken longitudinal narrow stripes, each making an elongated narrow band pointed at the ends.

As frequently occurs with specimens of brown body color, the decorations are most elaborate with lines, spots, and network about the head. Figures 1 and 2 of plate 2 show paintings of such a specimen. The ventral surface of this large *Navanax* is thickly set with oval spots, large and small. Those on the center form a continuous line of bright orange, breaking up into large rounded spots at either end.

The *spermatic groove* is clearly outlined from the vulvar opening forward, the pigmentation of the side of the body is a darker brown down to the upper border of the groove and is thickly sprinkled with small white spots. Beyond the groove the inner surface of the parapodium is a clouded lighter brown, becoming darker as the upper margin of the parapodium is approached. Penis sac everted. A deep depression is along the side of the dilated organ, at the bottom of which is the spermatic groove continuous out to the tip and along the hook-like glans to its apex.



*Measurements.* Following are measurements of living specimens taken at Corona del Mar, California, on the mud flats of Upper Bay, April, 1946:

<i>Specimen</i>	<i>Extended Length</i>	<i>Maximum Diameter</i>	<i>Remarks</i>
Largest	228 mm.	48 mm.	
Smallest	75 mm.	26 mm.	Left tail lobe longer
Intermediate	80 mm.	34 mm.	Left tail lobe longer
Intermediate	90 mm.	32 mm.	Left tail lobe longer
Intermediate	110 mm.	40 mm.	Tail lobes of equal length
Intermediate	130 mm.	38 mm.	Tail lobes of equal length
Intermediate	130 mm.	45 mm.	Tail lobes of equal length

The measurements of an alcoholic specimen of average size are as follows: over all length, 85 mm.; width, 30 mm.; height, 20 mm.; head shield length, 40 mm.; body shield length, 50 mm.; tail lobes of equal length, 15 mm. One very small specimen measures 35 mm. in length including the left tail lobe which is 10 mm. long.

The following collections have been recorded:

<i>Locality</i>	<i>Collector</i>	<i>Date</i>
San Diego Bay	Cooper	1861
Catalina Island	Dall	1873
San Diego, large specimen	Fred Baker	1897
Elkhorn Slough	G. E. MacGinitie	1927
Mission Bay, mud flats	Johnson and Snook	1927
Corona del Mar, Upper Bay	G. E. MacGinitie	1932
Elkhorn Slough, 5 specimens, living	Dixie Lee Ray	1942
Southern California and Mexico	Ricketts and Calvin	1942
Corona del Mar, Upper Bay	MacFarland	1946

The eggs are laid in light-yellow, stringy coils, woven together in pleasing design. An egg string from the aquarium, unraveled from the nidosome, is made up of segmentally arranged capsules, each surrounded by a transparent wall and containing 16 to 25 eggs. The string so unraveled measured 50 feet in length.

*Navanax* is voracious in attacking and swallowing whole *Haminoca* and smaller individuals of *Bulla*, only larger ones of the latter proving too large for its capacious gullet. After digesting its victim, the empty and unbroken shells are passed. The gastric teeth and radula of *Haminoca* are also egested.

## Suborder ANASPIDEA

### Family APLYSIIDAE

#### Genus *Aplysia* LINNAEUS

*Aplysia* LINNAEUS. 1767. Syst. Nat., ed. 12, p. 1072. Genotype, *Tethys depilans* Linnaeus. (After Pilsbry.)

#### *Aplysia californica* Cooper

Plate 3, figures 1-3; plate 6, figures 15-17; plate 8, figures 1-15; plate 9, figures 1-7

*Aplysia californica* COOPER. 1863. Proc. Calif. Acad. Nat. Sci., vol. 3, p. 57, 1 fig. "San Pedro, California."

#### EXTERNAL STRUCTURE, LIVING SPECIMEN.

*Body* plump, soft, flaccid, light gray-green, light to deep brown, red to red-violet; marked everywhere with a network of fine lines of dark brown connecting, irregularly, small rounded spots of variable size of the same color. Head narrow, without a shield; with two pair of flat or inrolled tentacles.

*Foot* smooth, narrow, truncate in front, with rounded angles, behind narrowing to a short, rounded tail; the sole of the general body color, smooth, or corrugated if in contraction.

*Parapodia* well developed, thick, the margin thin and undulating or frilled, the anterior ends well separated, the posterior ends fused transversely behind a low wall.

The inner surface of the parapodia is the general body color, but darker in tone and mottled to some extent with brown. The marginal zone thin, clear, and light, succeeded by a broad zone banded with irregular vertical extensions, sharp and clear in outline, of the darker color below. A crusting of white covers the light intermediate areas below. The basal length of the parapodia is two-thirds of the total length of the animal.

*Tentacles* well separated, directed outward and forward, long, auriculate, the opening extending from tip to base, upper hinder margin thick, inrolled, the lower anterior margin expanded, thin and undulating, its lower margin prolonged in front to the margins of the mouth opening.

*Rhinophores* long, tapering, blunt, the tip auriculate, the slit extending down the outer face for one-third to one-half the total length of the rhinophore. Bases broad, somewhat separated. The lining of the rhinophore cavity dark, the margins of the slit narrowly edged with pale yellow to white. Bases of rhinophores slightly nearer to the anterior end of the head than to the anterior ends of the parapodia.

*Eye* small, black, deeply imbedded in the integument, close below and in front of the rhinophore bases.

*Mantle* covering the dorsum between the parapodia, continuous with it on the left side without a definite limit; on the right side overlapping the gill and the branchial chamber by a narrow free margin, the posterior margin of which is expanded, inrolled, and projects upward between the parapodia as the anal siphon with a thin, crenulate margin. Anterior margin of the mantle prolonged forward as a median rounded process or anterior lobe in the interspace between the anterior ends of the parapodia. Shell cavity large, prolonged in front into the median lobe of the mantle. External opening of the shell cavity a minute, sub-central pore upon the summit of a low papilla, its margin finely lobulate and surrounded by fine, short radial ridges marked by short black lines, converging to the summit.

*Mantle cavity* roomy, extending above the large gill transversely beneath the mantle to nearly the left margin of the shell. Behind the gill and the siphon the cavity is deep and continues around to the left side.

*Anus* pocket-like, on posterior basal wall of siphon.

*Pallial chamber* very large and roomy, below the narrow overlapping edge of the mantle and the side of the body, bounded externally by the right parapodium. Color of its wall gray-green with irregular dark maculations or darker to brown or even very deep brown.

*Gill* large, falciform, on right side beneath the mantle margin; its tip extending backward into the cavity of the siphon. Edges of gill laminae very dark, the faces light brown.

*Osphradium.* A small inconspicuous patch of sensory epithelium at the anterior base of the gill, close to the union of the efferent branchial vein with the anterior gill margins.

*Opaline gland.* the "organ of Bohadsch," large, compact, its external opening a single large pore below the insertion of the gill, at the anterior end of the gill cavity.

*Purple gland* a large diffuse area bordering the under surface of the right mantle margin, its rich reddish purple secretion abundant.

*Reproductive opening* close to mid-line of the body just beneath the anterior edge of the mantle and well behind the anterior end of the parapodia, the strongly marked dark spermatic groove extending forward from it to the penial opening just below the base of the right tentacle.

*Color* range varying from clear red of young dredged specimens to browns and red-violet and to deep purple as found in the pools of southern waters. These are contrasted by the gray-green of mature specimens of Elkhorn Slough of Monterey Bay.

Each color variety is subdued by a clear network over the surface of fine darkened lines arising from rounded nodal points averaging 3 mm. in diameter. This is most striking upon the parapodia, traces persisting in alcoholic material. (Pl. 3, fig. 1.)

The pallial cavity is a darkened shade of the body color, becoming light and clear upon the open, curved edges of the parapodia. The dark color below extends upward to the margins as vertical extensions forming a banded zone, sharply contrasted against the light background. The light areas are encrusted with a fine spotting of white. This banded area of irregular markings upon the outrolled edges of the parapodia is constant in all specimens of *Aplysia californica*, and is the most striking feature. (Pl. 3, figs. 1, 2, 3.)

A line of white occurs along the edges of the parapodia, the siphon, around the open rhinophores, and extending out to the tips of the tentacles. Isolated spots of white occur upon the sides of some specimens and flame-like red markings are on some specimens.

Many living specimens have been studied for size and color; the external difference is largely one of these as the form is the same for each specimen of this species. The protection afforded by the coloring, in the seaweeds and kelp, is striking. The algae upon which they evidently feed is quite identical in coloring and doubtless the food is a decisive factor.

*Shell* (pl. 6, figs. 16, 17) broadly hatchet shaped, membranous translucent, somewhat arched, readily separable from the underlying surface of the shell cavity in preserved material, adhering only slightly in the region of the accessory plate and apex. Right side of the shell with a deep posterior sinus, the hinder margin much thickened and inrolled, its surface closely corrugated.

Accessory plate present, triangular to rhomboidal or spatulate in outline, arising from close below the shell apex and directed downward and backward, its left margin more completely united with the shell than the right one. Calcification very slight or entirely absent.

Translucent, very pale amber in color, central area light, bordered by a deeper amber zone which in turn is bounded by a broader transparent zone of pale amber. Radiating narrow lines of brown in the innermost shell layer pass outward from the apex through each of these three zones, most strongly marked in the central area and fading out in the outermost. These radiating lines are connected irregularly by numerous cross lines forming a network with elongated meshes.

*Dimensions* of the shell described above, from a specimen 300 mm. long, are, total length of shell, 85 mm.; width, 65 mm. Accessory plate is shaped as a widened triangle; the upper margin rounded and free, about 12 mm. wide at its widest point. The base passes under the shell tissue to the point of attachment below the apex. From this point to the upper free margin the distance is 10 mm.

In one large specimen, the shell was found free in the shell cavity and beneath it was found a second thin and very transparent shell attached to the floor of the cavity. The upper shell, 81 mm. long by 64 mm. wide, was fully formed with all the characteristics of the species, its lower, slightly smaller one measured 68 mm. in length by 58 mm. in width. Its central area is thinner than that of the upper shell and the nar-

row brown lines radiating from the apex are very faint and in part absent. No indications of any malformations were present accompanying the accessory shell.

J. G. Cooper (1863) in his description of this species stated: "There was no appearance of a multiplication of shells, said to occur in old specimens of *Aplysia*." Despite prolonged search through the literature issued before the time of publication of Cooper's paper, I have been unable to find any record of such shell duplication in *Aplysia*, nor have I found any in publications since then. If it is at all common, it should have been noted long ago since it is extremely improbable that it occurs in *Aplysia californica* alone. Just why and how such a development might take place is an interesting problem. So far as I am aware no similar duplication has ever been noted in allied mollusks.

*Dimensions.* These vary owing to the degree of muscular contraction of preserved specimens, as well as the age of the individual.

The largest specimen (taken at Elkhorn Slough in 1942) measured, in living state, as follows (pl. 3, fig. 3, the painted specimen):

Total length	400 mm.
Maximum height	200 mm.
Maximum width	180 mm.
Maximum width in front of parapodia	80 mm.
Length, anterior end of parapodia to velar margin	150 mm.
Anterior end of parapodia to base of rhinophores	60 mm.
Mid-base of rhinophores to mid-base of tentacles	80 mm.
Oblique distance from posterior end of parapodia to tip of tail	80 mm.
Maximum width of foot	44 mm.
Length of rhinophore	35 mm.
Tentacles, length	42 mm.

Other specimens were considerably larger.

Measurements, smallest specimen taken, fairly well expanded, dredged from Monterey Bay, 1904. Color, scarlet.

Total length	50 mm.
Maximum height	35 mm.
Anterior end of parapodia to rhinophores	9 mm.
Base of rhinophores to base of tentacles	12 mm.
Length of rhinophores	8 mm.
Length of tentacles	8.3 mm.

*Size.* *Aplysia californica* attains a size fairly gigantic among its fellows, reaching a total length of 750 mm., although such sizes are exceptional. MacGinitie (1935, pp. 737-738), in his excellent ecological study of Elkhorn Slough, recorded one measur-

ing 480 mm. in length, 260 mm. in height, and 170 mm. in width, and another with a weight of 15 pounds.

The animal occurs abundantly at times, rarely at others. It feeds on seaweed or, in the Elkhorn Slough, *Zostera*. In deep water its food is red algae, in shallow pools the brown forms.

Young specimens dredged in the bay are a crimson-red, while larger ones along the shore are gray mottled with green and brown in varying degrees. A similar relation of food, as influencing color, has been shown on the European *Aplysia punctata* by Garstang (1889-1891). It is probable that the red color, described by Cockerell (1901) as one of the specific differences of *Aplysia ritteri*, may be due to some similar cause, for the species is otherwise quite similar to *Aplysia californica*.

*Habitat.* The species has been recorded from the intertidal zone and taken by dredging along the coast from the San Francisco region (Bodega Bay, Hanna, 1939) to the Gulf of California. I have had two small specimens collected by E. F. Ricketts, 1941, one from El Mogote, Bay of La Paz, Baja California, the other from Puerto Refugio, Angel de la Guardia Island. In external features they present no differences from the usual characters shown in the species.

*Aplysia californica* may be found at times on rocky or sandy beaches exposed to the full force of the surf, but more abundantly on sheltered mud flats such as those of Elkhorn Slough, Monterey Bay. Ricketts (1939, p. 76) recorded young specimens as common under rocks in northern Baja California in February, and hosts of medium-sized ones were collected at Laguna Beach in May.

The eggs are deposited in long yellow tangled stringy masses. MacGinitie estimated that the total number of eggs in such a mass was approximately 86 million, and a single specimen weighing five pounds, kept in the aquarium for five months, laid approximately 478 million eggs.

The species was common at La Jolla, Laguna Beach, and Corona del Mar in the spring of 1946 (March-June). Eggs in masses were abundant.

#### INTERNAL ANATOMY.

*Alimentary canal.* The short muscular oesophagus dilates into the large thin-walled crop, distended but not filled with red, green, and brown alga material. Its wall shows no signs of glandular thickening.

Gizzard externally marked by a strong muscular band 14 mm. in width with an external diameter of 21 mm. Its first division, the first tritulating stomach, bears a number of large chitinous teeth, readily detached from the wall leaving their elevated impressions, their bases quadrangular.

The second tritulating stomach has a larger lumen, and a thinner wall with muscular bands predominantly circular in direction not longitudinal, as stated by Eales. Scattered, taller, more slender, and pointed teeth are borne on oval impressions some distance back of the zone of larger teeth. Apuleius, *Apologia sive de Magia*, ch. XXXX.



first noted the existence of gastric teeth. Bohadsch, 1761, first described the gastric teeth of *Aplysia*.

*Mandibles.* Lateral to the mouth opening the thick cuticle of the tube is replaced by the large and strong paired mandibles, each approximately an oblique parallelogram with rounded angles, deep brown in color in front and becoming somewhat lighter behind, its pale yellow posterior margin concealed within a deep sulcus or fold of the oral integument. In a large specimen, one mandible measured 15.5 mm. long and 10.5 mm. in maximum width. (Pl. 8, fig. 11.)

Each mandible is made up of an enormous number of closely set polygonal prisms or rodlets, each prism being the cuticular product of an individual epithelial cell or rhabdoplast at its base, and each one faintly striated transversely in correspondence with successive layers of chitin laid down by the rhabdoplast. A complete sequence of such stages is found in passing forward from the bottom of the sulcus. (Pl. 8, fig. 13.)

The epithelium of the opposite wall of the sulcus produces a continuous layer of chitin, its free surface resting against the tips of the rodlets. At the opening of the sulcus this cuticle is continuous with the general cuticle of the oral epithelium and projects forward beyond the sulcus boundary as a covering over the free ends of the rodlets terminating in a thin free margin beyond which the outer surface of the mandible appears.

Full development of the rodlets with a height of about 0.40 mm. and a diameter of 0.075 mm. is reached in a zone about midway of the length of the mandible. A homogeneous layer of cuticle now begins to be laid down by the epithelium uniting the rodlet bases with each other. (Pl. 8, figs. 14, 15.) This basal union increases in thickness and is continued forward beyond the anterior boundary of the mandible with the general thick labial cuticle. Near the boundary the rodlets show the effects of wear through use, and are worn, broken, and irregular. The total thickness of the mandible is largely made up of the homogeneous basal cuticle bearing the worn rodlets imbedded in its surface.

*Palatal spines.* The prolongation of the oesophagus forward at its entrance into the pharyngeal bulb forms a median groove extending behind the mandibles above the radula and is limited by a folded dorso-lateral thickening on either side. This is the "doccia faringea" of Zuccardi (1890), the pharyngeal groove and the ridges limiting it are his "creste faringee," or pharyngeal crests, for which terms Hoffmann (1938) would substitute palatal groove and palatal folds as better indicating their position. (Pl. 9, fig. 6.)

These palatal folds are light yellow in color in marked contrast to the black lining of the cavity above them. They extend forward above the odontophore, and bear a thick cuticular investment upon their columnar epithelium in which palatal spines are present. These are similar to those described for *Dolabella agassizii* by the writer (1918), and their development is similar. They are long, tapering and slightly recurved and are made up of a series of disk-like structures with a distinct longitudinal furrow or groove upon the posterior face. They vary in size, the largest reaching a length of from

0.15 to 0.264 mm. and a basal diameter of from 0.034 to 0.030 mm. (pl. 8, fig. 10; pl. 9, fig. 6).

These palatal spines together with the rodlets of the mandibles are termed "stick cells" by Eales (1921), manifestly a mistranslation of the Italian term "bastoncelli" used by Mazzarelli.

*Radula* broad, deeply grooved, anterior two-thirds everted and in functional use, dark brown in front, lighter behind. Teeth in 50-80 rows made up of a single median, and 38-65 laterals on either side. Formula 50-80 (38-65.1.38-65). (Pl. 8, figs. 1-9.)

Median tooth with quadrangular base, its posterior angles widely expanded laterally, posterior margin nearly straight or slightly concave, the anterior margin broadly notched. Cusp large, strong, directed upward and backward, with a variable number of short and irregular denticles on either side. (Pl. 8, fig. 4.)

Body of laterals broad, stout, the base directed obliquely outward and backward, its margin expanded outward into a thin wing overlapping slightly the base of the adjacent lateral (pl. 8, figs. 3, 7, 8). Body fairly uniform in size in the inner half of the row, thence progressively narrowing, the outermost six to eight decreasing rapidly in size and becoming rudimentary in the outermost three to four. Cusp long, sharply pointed, its denticulation variable, usually a large denticle on outer border near its base with smaller ones behind it, and quite small ones toward the tip of the cusp. On inner margin of cusp one or more strong denticles near the base with numerous quite small ones toward the tip. (Pl. 8, fig. 1.)

In general a high degree of variability in the number, size, and shape of the denticles is to be noted, both in the same radula and in different radulae.

*Reproductive system.* The *ovotestis* yellowish, closely adherent to the posterior and ventral surfaces of the liver. Its convoluted *hermaphroditic duct* passes forward, dilating into a whitish ampulla-like enlargement, and, contracting, opens into the fertilization chamber at the anterior end of the adnexed genital mass. This *complex* is elliptical (pl. 9, fig. 1), flattened dorso-ventrally, and is closely attached to the dorsal body-wall below the anterior end of the pallial cavity. In a flaccid preserved specimen of 250 mm. total length, it measured 21 mm. in length, 16 mm. in width, and 8 mm. in thickness.

The *spermatocyst* (*spc.*) is an elongate, sausage-shaped, thin-walled sac, that lies upon the left anterior margin of the complex; its slender duct, nearly equal to it in length, passes across the anterior border and enters the fertilization chamber at the proximal, dilated end of the vaginal duct. (Pl. 9, figs. 1, 2.) The closely convoluted surface of the *albumen gland* is nearly concealed by the broader windings of the *nidamental gland*. It opens into the fertilization chamber near the exit of the nidamental gland. (Pl. 9, fig. 2.)

The *large hermaphroditic duct* (pl. 9, fig. 1), some 50 mm. in length by 4-4.5 mm. in width, irregularly looped and somewhat twisted, passes forward from the left anterior border of the adnexed complex to the vulvar opening. It is made up of the



incompletely separated vaginal and spermatic ducts. (Pl. 9, fig. 1, *a-a*, *b-b*.) Close to the external opening it dilates into the *bursa seminalis*, which receives the long, thick-walled duct of the *spermatheca*. This is a large nearly spherical sac, usually flattened in preserved material, about 10 mm. in diameter, its duct 11 mm. long by 1.2 mm. in width.

The *external reproductive opening* is dorsal, just beneath the antero-lateral edge of the mantle, the exterior, ciliated spermatic groove extending forward from its anterior border and gradually curving downward to the male opening close below the right tentacle at the side of the head.

*Penis sheath* eversible, thick and muscular, the proximal end looped forward upon itself, its lining pigmented with light brown. (Pl. 9, fig. 3.) Along its inner wall a strongly developed ciliated groove, with very prominent margins, continues the external spermatic groove from the outer opening to the base, where it is continued along the ventral surface of the verge as a deep, narrow furrow to its tip. (Pl. 9, fig. 3.) Cross sections are shown in outline at *a*, *b*, *c*. in figure 4.

*Verge*, or *glans penis* when retracted, fills the proximal three-fourths of the sheath. In its basal portion it is somewhat cylindrical, but becomes flattened toward the tip. No armature is recognizable. (Pl. 9, fig. 5.) Inserted in the proximal end of the penis sheath is a strong retractor penis muscle, its origin the dorso-lateral body wall near the base of the right rhinophore. Other muscular bands extend from the outer face of the sheath to the lateral body wall.

### Genus *Phyllaplysia* FISCHER

*Phyllaplysia* FISCHER. 1872. Description d'une espèce nouvelle du genre *Phyllaplysia*. Journ. de Conchyl., Paris, vol. 20, p. 296.

### *Phyllaplysia taylori* Dall

Plate 3, figure 4; plate 8, figures 33-39; plate 9, figure 15

*Phyllaplysia taylori* DALL, 1900. On a genus (*Phyllaplysia*) new to the Pacific Coast. Nautilus, vol. 14, pp. 91-92.

In 1900, specimens of a tectibranch were collected from floating seagrass near Nanaimo, Vancouver Island, by George W. Taylor. Specimens were sent to Dall. Following are brief quotations from his description of the alcoholic material:

"The animal in most respects differs very little from *P. lafonti* Fischer, the type of the genus. It is subtranslucent, smooth, of a uniform pale lemon-yellow color, very much flattened, resembling some of the Planarian worms. . . . The 'rainure' extending from the right tentacle to the branchial opening is a plain line barely perceptible; the branchial pit with two minute lobes is short and in about the same relative position as in *P. lafonti*. . . . I propose for it the name of *Phyllaplysia taylori* in honor of its discoverer."

*Description.* Twenty-two specimens of a green tectibranch mollusk were dredged from the Monterey wharf in 1894. Later, in the same year, ten specimens were found feeding on Bryozoa on broad-leaf *Zostera*.

In captivity the animals were quite active, moving around in the aquarium with all tentacles extended; the anterior larger pair, apparently, being used as feelers.

*Body* elongate linear, 6 cm. long, 1.6 cm. wide, 8 mm. high in the center, bluntly round at the head and tail, foot as wide as the body.

*Head* well marked linear, bearing two pairs of tentacles inrolled, flattened, rounded above. The anterior pair are the larger.

On the right side of the dorsal posterior half of the length lies a longitudinal lunate opening, 10 mm. long, closed by a segment-like flap (reduced parapodia) from the side. This flap usually lies across the opening in such a manner as to leave an ovate opening at each end, the anterior, the branchial, and the posterior, the anal one.

*Color* of the body integument is a translucent gray. The body as a whole is a vivid green matching the *Zostera* upon which the animal lives, feeding upon the Bryozoa. A series of parallel lines, in interrupted pairs, pass along the full length of the mid-dorsum, continuing upon the head and tentacles where they break into irregular spots. A broken series of parallel lines also pass along the sides down to the edge of the mantle. These arise from the outside pair of the longitudinal series. These red-brown paired lines enclose a light area, almost white. Bright blue-green tips the anterior tentacles and the rhinophores; a narrow white line borders the mantle margin within which is an area of the translucent gray. The ventral surface of the foot is a very light green. There may be a series of transverse lines passing laterally to the margins; however, these are not present on all specimens. Alcoholic material, from Monterey Bay and northward, is clearly marked by these; the specimen used for the painted figure, taken from Newport Bay, did not show these.

*Mouth* on the under side of the head, triangular in shape, is bounded in front by a veil with angular points and bilobed by a deep notch in the median line.

The *eyes* lie immediately in front of the second, smaller, pair of tentacles.

A deep longitudinal *groove* extends laterally from the branchial opening forward to the side of the head and connects with the reproductive openings.

*Mantle fold.* On the axial side, immediately beneath the epipodium, lies the thin, reduced mantle fold, covering the ctenidium. This fold is larger than the epipodium immediately above it and posteriorly bears a thickened margin in which lies the anal opening. The latter is directed upward and outward and terminates in the anal-excurrent orifice of the branchial chamber.

The *branchial chamber* is oval in form, 6 mm. in length with a greatest transverse diameter of 3.6 mm. and a depth of 3.4 mm.

The *ctenidium* has a triangular flattened axial portion. The longest free portion is 8 mm. It is 5 mm. long at the base (the point of attachment). The outer side bears six groups of lobate gill plates. Alternating in position with these, on the inner surface, are five similar groups.

At its outer lower border, at the point of insertion, is a yellowish spot, perhaps Spengel's osphradium?

*Dimensions.* The living specimen depicted in figure 4 of plate 3 had the following dimensions: length over all 50 mm., body width 11.5 mm., foot width 10 mm., height 6.7 mm., rhinophore length 5 mm., tentacles length 8 mm., gill opening 8 mm. long.

Alcoholic specimens: large, 47, 45, 40 mm. long by 10, 10, 6 mm. in width.

Alcoholic specimens: small, 16, 7, 5 mm. in length by 8, 2, 2 mm. in width.

*Habitat.* Readily found feeding upon the Bryozoa living upon the broad-leaved *Zostera*. Specimens of *Phyllaplysia taylori* have been collected in large numbers at Nanaimo, Vancouver Island, and southward to the San Diego region where *Zostera* thrives in abundance.

*Protective coloring.* This attractive tectibranch is a perfect example of protective coloring in relation to its habitat. The longitudinal lines are found both on the animal and *Zostera*, and frequently the cross lines of the latter are repeated on the tectibranch. They are identical in coloring. The animal flattened full length upon the leaf can be seen only as a shadow.

Nidosomes are laid upon the *Zostera* leaves in flat, transparent, rectangular disks as wide as the habitat grass,  $4\frac{1}{2}$ –5 mm. wide by 13 mm. in length. Each egg is inclosed in a separate capsule attached in a continuous string.

#### INTERNAL ANATOMY.

*Mouth and pharyngeal bulb.* The mouth communicates by a short tube with the pharyngeal bulb which is elongate, oval in form, measuring in a larger individual, 5.5 to 6 mm. in length, 4 mm. in width, and the same in height. The ventro-lateral and posterior parts of the bulb are the most muscular portion, the dorsal wall being composed of folds of the oesophagus. When the bulb is opened from above, the amber-colored radula is exposed; in front and on either side, are the mandibular plates of a similar color. Each one of these is proportionately longer than wide, with rounded ends. Back of these are narrow, strap-like bands of hooks covering the folds on the ventral side of the buccal mass.

Above, the mandibles almost meet in the median line; below they are separated by a considerable interval, about one-third the distance of their height. Each is made up of the thickening of the cuticle in the form of closely set cylindrical rodlets, free at their outer ends, but imbedded in a common, narrow, basal cuticle covering the distal ends of the cylindrical cells which produce them.

The mandibular plates are roughly triangular in shape. The greatest length of the anterior margin is 1.8 mm., the posterior margin being 1.4 mm. in length. The anterior margins are irregular and worn, much folded as the mouth is contracted. The posterior margins are smooth, slightly rounded in outline, very thin, and transparent.

These plates vary in width at the ends. At the base, where they are separated, the narrow one being in width .22 mm., the wider one .45 mm. At the top, where the plates are almost in contact, they measure .18 and .22 mm. in width, respectively.

*Radula.* (Pl. 8, figs. 33-39.) The ventral portion of the radula extends forward in the pharyngeal bulb half its length, occupying the lateral and posterior portions. It is rolled so that the dorsal edges are quite close; the lateral and ventral anterior edges are slightly curved posteriorly. The lateral and ventral posterior portions are deeply reflected anteriorly so that the outer posterior surface of the bulb has a ring-like appearance.

When flattened in a mount, the radula is roughly rectangular in shape, the greatest length being 3.5 mm., width 5.5 mm. The color is pale amber in the anterior or older portions but becomes quite transparent in the posterior or newer portions. The anterior rows are worn and somewhat broken, showing cusps and denticles much blunted and sometimes irregular and jagged in outline. There are 27 such anterior rows followed by 16 perfect rows, 13 of which are under the radula sheath. The total number of rows is 43.

The number of teeth in the most anterior rows is quite small, from 2 to 4 laterals in the first row. The number increases with striking regularity until the 27th row is reached. The 16 perfect rows show a fairly constant number of teeth. The 13 rows under the radula sheath have an average of 58 laterals, all of which show cusps and denticles very long with even outlines.

The rachis bears a single tooth in each row, smaller than the laterals and of quite a different shape. (Pl. 8, fig. 33.) Its base is trapezoidal in form, the posterior external angles being prolonged outward and backward in two long divergent limbs which may attain a length equal to the base itself. The tips of these prolongations measure from .06 to .09 mm. apart.

The base, in outline, is concave in cross section; it is much thinner and flatter in the center, the lateral and prolonged portions being somewhat thickened and higher. The anterior end of the base is recurved dorsally in a strong hook which narrows slightly as it curves upward and backward. This hook is bluntly triangular in shape and has an average length of .0225 mm. It terminates in a median cusp, which may be quite pointed, and two denticles on either side generally rounded. The outer denticle is usually smaller and not so well developed as the inner or first one. These two rounded denticles, as well as the median cusp, are quite thickened and blunt as seen in side view. The ridge prolonged from the median cusp is often quite pointed as it curves downward over the hook, while the ridges terminating in the first lateral denticles are rounded.

The first laterals are more obliquely set and slightly smaller than the succeeding laterals. In the first 15 to 18 rows these laterals are quite uniform in size. In the suc-

ceeding rows, until the complete ones are reached, these laterals decrease slightly and uniformly to the outermost ones. In that part of the radula under the sheath, the laterals are quite uniform in size throughout, for one-third the length of the rows; from this point a uniform decrease takes place until the small outermost ones are reached. (Pl. 8, figs. 35, 36.)

The laterals bear a wing-like extension of the base which passes into a thickened portion near the center, terminating in knob-like projections. (Pl. 8, figs. 33, 35.) This, curving forward, is prolonged into a strong hook, recurving dorsally into a broad cusp with a denticle on either side, the inner one larger.

In general the cusp of the lateral is broad and long, terminating in a square margin which may have a slightly folded appearance. The inner denticle may be as long as the cusp but usually is shorter and somewhat pointed. The outer denticle is small and pointed except when worn. (Pl. 8, fig. 34.)

*Dimensions.* The first laterals have the base varying from .09 to .105 mm. in length, width being uniformly .045 mm. Hooks vary in the older to newer portion from .03 to .06 mm. in length. Largest laterals have a base .135 mm. long, .075 mm. wide; with the hook from .03 to .09 mm. in length. The smallest laterals have a base .054 mm. long, .012 mm. wide; the hook varies from .007 mm., oldest portion, to .025 mm. under the sheath, in length.

#### HISTOLOGY BASED ON SERIAL SECTIONS.

*Reproductive system* (pl. 9, fig. 15). The reproductive system in the Aplysiidae is made up of the following organs:

1. The ovotestis or hermaphroditic gland
2. The small hermaphroditic duct
3. The adnexed genital glands, including
  - a) The fertilization chamber
  - b) The nidamental gland
  - c) The albumen gland
4. The spermatocyst and its duct
5. The large hermaphroditic duct, a double canal, made up of
  - a) The copulatory duct
  - b) The ovo-deferens duct
6. The spermatheca and its duct
7. The vaginal duct
8. The external genital groove
9. The penis

The anatomy of this system has been made the subject of extended study by Robert Saint Loupquiart, by Vayssière, and especially by Mazzarelli in the typical Aplysiidae. In *Phyllaplysia*, the system is not so well known. In the following description the different parts will be taken up in the order given above, *i.e.*, from posterior end of the body forward.

The *ovotestis* or hermaphroditic gland occupies the posterior one-third to one-half of the body cavity. In form it is bluntly conical, its longitudinal axis being slightly curved toward the right (dorso-laterally).

Posteriorly it terminates in a bluntly rounded tip which is about one-third the diameter of the anterior end. The convex pinkish surface is marked off everywhere into irregular lobes, which are, in turn, divided into small lobules. The anterior end is irregularly truncate and presents a series of facets and depressions caused by the pressure of the organs in contact with it in front and above. An irregular dorso-ventral fissure divides this portion into right and left anterior lobes and is prolonged backward upon the dorsal surface as a decreasingly shallow depression. This groove is filled below with the windings of the posterior end of the small hermaphroditic duct and above by the posterior end of the liver, the tip of which is prolonged backward and imbedded in the dorsal prolongation of the groove. From between the anterior lobes of the ovotestis the small hermaphroditic duct emerges. This common channel for eggs and sperm arises by the union of minute tubules which come from each of the lobules.

In diameter, the main duct varies from 0.5 mm. to 2 mm., its length being about .20 mm. Its course is tortuous, being thrown into a number of irregular loops and windings as it passes forward to the adnexed genital glands. The small hermaphroditic duct, throughout the greater part of its extent, is lined by a low, ciliated, cubical epithelium with large spherical nuclei, resting upon a delicate basement membrane. The epithelium contains a strongly marked chromatin network. The cilia are very long, 5 microns in length, equaling the height of the cells, and in some parts being much longer. The remainder of the wall of the duct is composed of a firm connective tissue with interspersed smooth muscle fibers interlacing in various directions. In all specimens sectioned, the duct was packed with a mass of spermatozoa.

The *small hermaphroditic duct* passes forward in closely convoluted windings to a point about midway of the inner face of the genital mass which it then penetrates and passes forward at the bottom of the groove occupied by the spermatocyst. Here it is imbedded in the connective tissue of the complex. Opposite the anterior end of the spermatocyst, the small hermaphroditic duct curves transversely between the proximal end of the large hermaphroditic duct and the complex, thence forward to the anterior end of the latter where it passes forming a loop around the albumen gland, backward and inward again for a short distance, to open into the fertilization chamber. In this region the wall of the duct becomes very thin, being reduced to but little more than a low ciliated epithelium.

In dissections, the small hermaphroditic duct seems to become rapidly narrow as it passes between the proximal end of the large hermaphroditic duct and the anterior lobe of the albumen gland. Serial sections show a remarkable internal valve-like structure in this region, the significance of which is not altogether clear. The lumen does not form a continuous cavity, as expected from the external appearance, but is traversed by an oblique wall from side to side, this septum being pierced by an oblong opening very short and narrow. The general epithelium is very low but becomes thicker toward the



opening. At one side of this, a group of peculiar gland cells is shown, containing a yellow secretion. At first but few, these cells increase steadily in number, rapidly replacing the low ciliated variety, until the latter become reduced to a narrow longitudinal groove upon one side of the duct. With this structure, the duct opens into the fertilization chamber close to the duct of the albumen gland.

The *adnexed genital mass* is an oval complex situated slightly to the right of the median line and about midway of the length of the body. Its greatest length is about 7.5 mm., its maximum diameter 4.0 mm. The irregular surface presents a strongly convex ventro-lateral face, directed toward the right lower side, and the slightly concave face which is turned inward toward the median plane of the body. The intersection of these two faces forms a rather sharp line nearly elliptical in contour. The anterior mass of the liver, the distal windings of the small hermaphroditic duct, and the spermatocyst with its duct, rest against the concave face, the convex outer one being in contact with the body wall.

The adnexed genital mass is made largely of the *fertilization chamber*, and the *nidamental* and *albumen* glands. The small hermaphroditic duct passes forward beneath the spermatocyst on the concave inner face of the complex to its anterior margin, abruptly narrowing in diameter to 0.2 mm. for a distance of approximately 1 mm., loops back dorsally, and passes inward, disappearing from surface view. Sections show that it opens directly into an irregular cavity, the fertilization chamber. A portion of the external wall of the cavity is visible upon the anterior portion of the convex face.

Into this cavity open also the duct of Cuvier and the ducts of the albumen and nidamental glands. Close to the entrance of the small hermaphroditic duct into the fertilization chamber, is found the opening of the duct of Cuvier of the spermatocyst which receives also the proximal end of the right half of the large hermaphroditic duct, as will be described later on.

The *albumen gland* is very large, forming the anterior and outer portions of the adnexed genital mass, and in some specimens extending in a triangular form entirely to the posterior extremity. At the anterior end its surface is divided into a smaller and larger lobe by the small hermaphroditic duct which describes a loop about it. Its cavity is large and irregular, the walls thick and thrown into thin folds which project as flat leaves into the cavity of the gland. This leaves the small central area free which contains more or less of the coagulated secretion of the gland cells. The typical cells of the albumen gland are columnar in shape, from 35 to 40 $\mu$  in height and 20 $\mu$  in diameter. The basal one-third to one-half of these cells is occupied by a dense cytoplasm in which is situated the large spherical nucleus containing a large nucleolus and finely divided chromatin granules. The outer portion of the cell is occupied almost entirely by the secretion granules closely packed together with a delicate network of cytoplasm. The granules present the general staining characteristics of albumen and range in size up to 1.5 $\mu$  from extremely small ones. A very thin capsule of connective tissue incloses the gland, and from it very thin extensions are prolonged into the folds forming the frame-

work upon which the gland cells are carried. The duct of the gland, by which it communicates with the fertilization chamber, is lined by a single layer of low ciliated epithelium. Its cells average  $11\mu$  in height and bear very long cilia which in some places reach the length of twice that of the cell from which they arise. The nuclei are elliptical, one-third the length of the cell. Projecting into this epithelium at intervals are large nerve cells. This duct opens into the fertilization chamber close to the entrance of the duct of the spermatocyst.

The *spermatocyst* is an elongated elliptical sac resting in a depression on the median concave face of the adnexed genital mass. In length it is about two-thirds that of the entire complex, being 3 to 4 mm. long and 1 to 1.5 mm. in diameter. Its duct, the so-called "duct of Cuvier," arises from the anterior end of the spermatocyst, passes forward, and opens into the fertilization chamber at the anterior end of the complex. Just before reaching the latter it receives the proximal end of the copulatory duct. The wall of the spermatocyst is made up of an inner epithelial layer, a strongly developed muscular layer, and a very delicate outer connective-tissue capsule. The two outermost layers average  $16.5\mu$  in thickness. The interesting features, however, are presented by the epithelial lining. This is a single layer of high columnar ciliated cells from  $8\mu$  to  $27\mu$  in height. The spermatozoa, with which the cyst is packed, are all arranged radially with their heads directed outward toward the epithelium and buried in the cilia of the latter. The sperm, at intervals, appears to penetrate deeper into depressions in the epithelium in conical masses. The distal ends of the epithelia are quite difficult to determine and their cilia are usually indistinguishably merged with the heads of the spermatozoa. The general arrangement is strikingly suggestive of the relation which exists between the developing spermatozoa and the cells of Sertoli in mammalian spermatogenesis. The duct of Cuvier arises from the distal end of the spermatocyst and gradually tapers to a diameter of  $180\mu$ . The epithelium is, at first, of the same general structure as that lining the spermatocyst, but exhibits closely set, wide, follicular depressions of irregular shape, which gradually elongate and merge into each other, the boundary epithelium of these crypts being thus converted into a number of longitudinal ridges. The cells become reduced to cubical form,  $6.6\mu$  in height and bearing cilia of nearly equal length. The muscular wall is relatively strong,  $20\mu$  in thickness. But, as the union with the proximal portion of the copulatory duct approaches, the musculature thins away until no distinctive layer remains as the tube becomes imbedded in the connective tissue of the adnexed genital complex.

The *large hermaphroditic duct* passes forward from the anterior end of the adnexed genital complex in a somewhat direct course to the region of the external reproductive opening, where it becomes convoluted and involved with certain accessory glandular structures.

In length, the free portion of the duct measures some 11.6 mm. in a fully developed specimen, its width varying from 0.8 mm. to 1.5 mm.

The duct is clearly defined in the adnexed genital complex as the nidamental gland, the greatly enlarged female portion showing a thin ciliated groove following its



entire length. This channel becomes the oviducal path as the large hermaphroditic duct passes to its external opening.

### Genus *Aclesia* RANG

*Aclesia* RANG. 1828. Hist. Nat. Aplysiens, p. 68. Genotype, *Bursatella savignana* Audouin, 1826.

#### *Aclesia rickettsi* MacFarland, new species

Plate 6, figure 9; plate 8, figures 16-25; plate 9, figures 8-12

We have specimens collected by E. F. Ricketts in the Gulf of California and designated by the numbers 3 and 7. The description uses the characters of both.

*Body* plump, high, broadest in the gill region, tapering forward, somewhat compressed laterally. Dorsal and lateral surfaces with numerous large and small tubercles, low and rounded toward the foot margin, becoming higher and conical or more filiform above, the largest ones with short lateral branches, either simple or in turn branching and arborescent. The largest of these are on the dorsal surface and near the margins of the parapodial lobes. (Pl. 6, fig. 9.)

*Foot* narrow, rounded in front, the anterior margin bilabiate. (Pl. 9, fig. 11.)

*Tail* short and rounded in one specimen (3) the type, having been injured at some time; in the second specimen the tail is larger and pointed. No posterior median pedal gland present.

*Parapodial lobes* broadly united behind, closing the gill cavity, the branchial slit 9 mm. long, rounded behind, narrowed midway and dilated in front, the thick parapodial lobes approaching each other, but not uniting in the median line, the genital opening well in front of their ends; the anterior end of the branchial slit 10.5 mm. behind the rhinophores. Several small simple and branched papillae at and near the margins of the parapodial lobes, a large arborescent one close to the margin of each lobe, another similar one on each side of the posterior of the cleft, and a smaller one opposite the anterior ends of the lobes. These form a vaguely defined longitudinal row on each side with smaller ones along the back behind the rhinophores. (Pl. 6, fig. 9.)

*The parapodial cavity* not large, extending a short distance behind the union of the parapodia, ending behind their ends, laterally extending on the right below the gill for a short distance downward, on the left a much shorter distance. The parapodial cavity is much smaller than that in *Notarchus* in which it extends below and around the body enveloping it in a roomy sac, united in front only with the parapodial walls and the foot. It is proportionately less roomy than in *Aplysia* but considerably larger than in *Phyllaplysia*. The cavity is not extended ventrally below the visceral mass to the opposite side, with the latter suspended in it by its anterior portion and floating freely in it, as implied in Pelseneer's diagram.

*Anterior tentacles* well separated, cylindro-conic, inrolled wide plates, the tips rounded, bearing a number of short, tuberculate or slightly branched processes. (Pl. 9, fig. 11.)

*Rhinophores* cylindro-conical, the tip bluntly rounded, deeply grooved externally from the tip halfway down to the base; surface of rhinophore with a few papillae, simple or long and branched. Rhinophore bases close together, separated by an interval equal to their basal diameter. (Pl. 9, fig. 12.)

*Mouth* a vertical slit, lips moderately fleshy, each one prolonged outward and downward in a thickened lobe which, at first united with the side of the head, becomes free as a rounded process extending below and beyond the base of the anterior tentacle. This process or so-called labial tentacle, appears to be characteristic of *Aclesia* but is absent in *Notarchus*. (Pl. 9, fig. 11.)

*Eye* small, black, conspicuous, in front of and below the base of the rhinophore.

*Common genital opening* close to and slightly to the right of the median line of the dorsum and in front of the anterior ends of the parapodial lobes and the anterior margin of the parapodial cavity. The spermatic groove passes forward and outward in a long curve below the base of the right rhinophore and the eye, to the external opening of the preputial sac below and behind the right anterior tentacle, and almost directly above the end of the foot. The dorsal lip of the groove projects as a distinct ridge above its ventral fellow. (Pl. 6, fig. 9.)

*Mantle* rudimentary as a thin layer covering the heart and kidney on the left dorsal surface of the body within the parapodial cavity, and extending to the mid-line in front. From here its slightly thickened pigmented free border extends as a low ridge backward, curving around to the left beyond the pericardium, then recurving to the right, passes to the rectal tube which projects as a short blunt cylinder in the hinder end of the parapodial opening. The pigmented zone of the mantle margin is continued below the rectal tube, becoming more diffuse as it merges with the ventral floor of the hinder branchial chamber.

*Gill* (pl. 9, fig. 10) crescentic in outline, made up of a median triangular plate attached to the left wall of the branchial cavity as a sort of shelf. Its free portion projects from about the mid-line of the body, curving to the right and backward, its free tip extending back on the right side to slightly behind the anal tube. Upon this plate, dorsally and ventrally, 10 to 12 close groups of gill lamellae are borne, each group receiving an afferent branch vein from the basal plate at its inner origin and giving off a main efferent vein at its anterior or outer margin. The proximal end of the gill arises beneath the hinder margin of the mantle, the first group of lamellae being concealed almost entirely beneath it, when seen from above.

*Pharyngeal bulb* nearly spherical. Along its mid-dorsal wall is a groove extending backward from the mouth opening and widening behind to inclose the opening of

the oesophagus. The groove is bounded laterally by a distinct palatal fold of the pharyngeal integument bearing a band of closely set cuticular spines, commencing close behind the mandibles and extending backward to the anterior end of the oesophageal opening. (Pl. 8, fig. 24, at *d*.) These palatal spines are much compressed strong hooks with long, narrow bases and recurved pointed tips arranged in longitudinal rows. These spines vary considerably in size, the basal length of the largest of these reaches 0.036 mm. with a height of from 0.025 to 0.030 mm., while the smallest are nearly straight and slender. (Pl. 8, fig. 25.)

*Mandibles.* A light brown squarish plate 1.1 mm. wide by 0.9 mm. long on either side of the mouth opening at the anterior end of the pharyngeal bulb. Made up of short, closely set, blunt, prismatic rodlets, longest at the anterior edge of the mandible and decreasing in length toward the posterior end where they are formed in a shallow sulcus or invagination of the mouth epithelium, each rodlet being the distal product of a single cell, as in other Aplysiidae. (Pl. 8, figs. 22, 23 at *m*.)

*Radula.* (Pl. 8, figs. 16-21.) Relatively broad, deeply grooved in the mid-line, of a light-brown or amber color in the anterior part. Teeth in 29 rows, the first 12-13 of which are functional in the anterior end of the organ, the remaining ones beneath the radular membrane, the youngest two rows, incompletely developed. The median tooth is of the form characteristic of the family. Its broad base is trapezoidal in outline, the posterior angles widely produced and divergent, the hinder margin concave. (Pl. 8, fig. 16.) From the anterior end, the strong recurved hook rises, its anterior surface deeply grooved in the median line. Two strong denticles are borne on either side of the base of the pointed median cusp, and a third much smaller denticle may appear on the median cusp in the younger radula rows, either as distinct structures or as irregular widenings of the cusp margins. The first lateral tooth consists of a stout oblique base parallel to the outer margin of the base of the median tooth, and a stout hook arising at right angles to the base and curving backward, ending in a bluntly pointed cusp. The inner margin of the hook is smooth (pl. 8, figs. 16, 18); from its outer face arises a stout triangular denticle and beyond it a broad, flat, hatchet-shaped one, in the younger rows even exceeding the main cusp in length. Successive laterals outward, from the first, show a lengthening and blunting of the cusp. (Pl. 8, figs. 16, 19, 20.) Beyond the sixth or eighth lateral, the whole tooth becomes progressively more and more compressed, the hook lengthens, and the cusp and lateral denticles become more slender. Toward the outer end of the row, the teeth diminish in size, are much more compressed, and the hook becomes much more erect, the denticles in the outermost two or three being reduced to an irregular serrulation, distinguishable only with strong magnification. The outermost tooth is a diminutive rudiment, showing a short base and a small, blunt, erect hook. (Pl. 8, fig. 17.)

*Color* of preserved specimen, pale yellowish everywhere, sparsely sprinkled on sides and back with small (up to 0.5 mm.) rounded or oval dead-white spots vaguely arranged in longitudinal rows.

Below and parallel with the genital furrow on the right side is a series of four to five incomplete, very narrow, parallel lines of dark brown, extending forward from the region of the genital opening to the anterior side of the head behind the anterior tentacle base. Traces of similar, faint, narrow, longitudinal lines may be made out with a lens upon the head from the rhinophores forward, a few extending up the anterior base of the rhinophores.

*Dimensions.* specimen No. 3. Length of foot 21 mm., width of anterior end 6.4 mm., maximum width midway of body 9.4 mm., highest point 22 mm. from anterior end. Highest point of parapodia from sole of foot edge, 11.7 mm., midway of body. Anterior tentacles 3.7 mm. in length, basal diameter 2 mm. Rhinophores 5 mm. in length, bases separated by 0.8 mm., basal diameter 1 mm. Parapodial lobes low, thick, opening 9 mm. long; anterior ends of lobes 1.8 mm. apart. Rhinophores cylindro-conical, the tip bluntly rounded; stalk bearing branches.

*Dimensions.* specimen No. 7. Total length 33.2 mm. Foot length 28.5 mm., width at anterior end 6 mm., maximum width midway of body 9.7 mm. Height, sole of foot to edge of parapodia 12.4 mm., midway of body length. Anterior tentacles 2.3 mm. in length; rhinophores 3.7 mm. in length, bases separated by .8 mm. Parapodial lobes low, thick, opening 6.6 mm. long, anterior ends 4 mm. apart, posterior ends 1.8 mm. Specimen used in dissection.

*Habitat.* Two specimens collected by E. F. Ricketts from the Gulf of California. One specimen, designated as No. 3, taken from boulder shore south of Point Lobos, Espíritu Santo Island, March 20, 1940. Second specimen, No. 7, taken from rocky shore one mile north of La Paz Bay, March 21, 1940.

The *reproductive organs* (specimen Number 7) of *Aclesia* are in general of the type found in other better known Aplysiidae which have been described in detail by Mazzarelli (1893), Guiart (1901), MacFarland (1909), Eales (1923), and others. Griffin (1912) has described their anatomy in *Aclesia freeri*, a closely related form, and important details have been indicated by Engel (1936) and by Eales and Engel (1935). Here no attempt will be made to enter upon a detailed discussion, important points of difference only will be emphasized. The parts involved are as follows: (pl. 9, figs. 8, 9).

- |                              |                              |
|------------------------------|------------------------------|
| 1. Ovitestis                 | 7. Mucous gland              |
| 2. Small hermaphroditic duct | 8. Spermatocyst              |
| 3. Fertilization chamber     | 9. Large hermaphroditic duct |
| 4. Gland complex             | 10. Spermatheca              |
| 5. Convoluted duct           | 11. External spermatogroove  |
| 6. Albumen gland             | 12. Penis                    |

The *ovitestis* is a finely lobulated somewhat hemispherical organ overlapping the hinder end of the liver, a deep groove on its left posterior face fitting closely around a loop of the intestine. In alcoholic material it is pale yellow in color.

From between its anterior lobules arises the closely convoluted whitish *hermaphroditic duct* which passes forward to the front end of the anterior genital mass. (Pl. 9, figs. 8, 9.) Passing beneath the broad ovo-spermatic duct, it rapidly narrows to about one-third the diameter of the convoluted portion, loops upward dorsally around the duct of the spermatocyst, and then returns backward and downward across the anterior genital mass to its left ventral border.

Here it branches into two divisions, the anterior one receiving the duct of the spermatocyst, the other entering the fertilization chamber, the relations of which are best made out in serial sections.

The *fertilization chamber* receives the broad opening of the albumen gland and continues into the small convoluted duct upon the right anterior ventral face of the mass and then expands into the lumen of the broad mucous gland loops, continuing forward beyond this as the oviducal portion of the large hermaphroditic duct.

The *gland complex* is somewhat heart shaped; about 2.5 mm. in length, 1.6 mm. in the greatest width near the anterior end. It is formed of the V-shaped loop of the mucous gland, which incloses the many small convolutions of the much smaller albumen gland. This continues forward from its right anterior lobe into the large hermaphroditic duct.

The *spermatocyst* projects to the left from the anterior end of the adnexed genital mass as a broad loop, returning upon itself and bending forward to its blind extremity. It forms a thin-walled lobular sac, crowded with spermatozoa, showing scarcely a distinction in diameter between its duct and the spermatocyst proper. Its duct connects with the internal seminal groove of the *large hermaphroditic duct*. As it passes from the adnexed glands to the exterior, the opening is broad, somewhat flattened, and spirally twisted. As in other better-known Aplysiidae, its lumen is incompletely divided into two channels by folds from the lateral walls: one of these is the oviduct, the other the spermatic duct.

Just before reaching the external opening, the *large hermaphroditic duct* bends downward, then forms a close loop forward and upward, passing to the vulvar opening with a slightly dilated vaginal segment. (Pl. 9, fig. 9. *vag.*) This dilation may correspond to the *bursa seminalis*.

Into it opens the long, slender duct of the *spermatheca*, a spherical thin-walled sac lying close to the integument at the left of the vulva. It is 1.5 mm. in diameter; its very slender duct is 4.5 mm. in length and describes a loop around below the large hermaphroditic duct, returning to its dorsal surface and opening into the bend of the duct or *bursa seminalis*.

The common *genital aperture* is slightly to the right of the median line of the body and well in front of the anterior ends of the parapodial lobes, not between them as in *Notarchus*, *Bursatella*, and *Barnardaclesia*.

The well defined external spermatic groove passes from it forward and down-



ward below the right rhinophore and eye, to the male opening at the side of the head close behind the base of the right anterior tentacle. The upper margin of the external groove is more prominent than the lower one and overhangs it as a distinct ridge. It terminates at the anterior opening as a rounded lobe beneath which the opening of the penis sheath is found. (Pl. 6, fig. 9.)

The *penis* consists of the *preputium* and the contained *glans penis*. The preputium is an elongated thin muscular sac, slender at first, slightly twisted and dilated toward its proximal end, then narrowing toward the base to which is attached externally a long retractor penis muscle which arises from the body wall. Along its inner wall the spermatic groove with prominent thickened margins is continued from the external opening to its proximal end.

Within the *preputium* is the long *glans penis* filling its cavity and extending nearly to its external opening from its origin at the base. It is flattened and twisted, and tapers to a rather bluntly pointed tip. The spermatic groove is continued from its base to the tip of the glans. Scattered over the glans in fairly distinct rows are a great number of low, cuticular *spines*, their pointed tips directed slightly backward. These spines may reach a height of 0.036 to 0.042 mm. and a basal antero-posterior diameter of 0.015 to 0.021 mm. They are at the summits of very low papillae and show no evidence of surmounting wart-like elevations such as figured by Eales and Engel (1935) for *Bursatella* and *Barnardaclesia*; nor is a *basal penial collar* or fold of the preputial wall, incompletely surrounding the base of glans and bearing similar spines, to be found. The spines of the glans extend nearly to its tip, which is free from them.

Scattered spines similar to those of the glans are also found sparsely distributed along the inner surface of the preputium, apparently without regular arrangement.

While the penis was totally retracted into the preputium in the two specimens at hand, it is evident that the organ is capable of complete eversion, in which condition the glans would be borne at the summit of the everted penial sheath or preputium. Such eversion is doubtless caused and maintained by increased pressure upon the blood surrounding the organ through local contractions. Retractor muscle inserted well back in body wall. Length of glans 6.0 mm., approximately. Basal diameter of glans 0.9 mm.

### Subfamily DOLABELLINAE

#### Genus *Dolabella* LAMARCK

*Dolabella* LAMARCK, 1801. *Système anim. sans vertebres*, p. 62. Genotype, *Dolabella callosa* Lamarck.

#### *Dolabella californica* Stearns

Plate 6, figure 14; plate 8, figures 26-32; plate 9, figures 13, 14

*Dolabella californica* STEARNS, 1878. Description of a New Species of *Dolabella*, from the Gulf of California with Remarks on other Rare or Little Known Species from the Same Region. *Proc. Acad. Nat. Sci. Philadelphia*, vol. 30, pp. 395-401, pl. 7.

Two specimens collected by E. F. Ricketts were used, designated by the numbers 10 and 26. The label on No. 10 reads: "March 26, 1940, Puerto Escondido [Baja California]. Large sea hare, extruding the usual purple ink."

DESCRIPTION OF SPECIMEN No. 10.

The *body* was contracted to 130 mm. length from 223 mm. in life. Head strongly contracted, concealing rhinophores and tentacles, foot corrugated in hinder half and in front, sides of body tumid.

*Mouth*, a deep vertical groove continuous below to contracted foot, lips tense and full.

*Disk*, 98 mm. at widest point, 74 mm. high, the prominent posterior end of the dorsal slit nearly central, its margins thin and erect. Margin of disk a well marked undulating wall, highest below and continuous above nearly to the parapodial margin. Posterior median notch of foot obscured by the great contraction of its surface; tail missing.

*Color*, everywhere brown with rounded patches of deeper brown scattered irregularly. Foot uniform dark brown on the sides into which it passes without any boundary line of demarcation. Surface rugose and warty.

*Spermatic groove* obscured by contraction, adjacent lateral and dorsal surfaces smooth or slightly rugose.

*Dissection*. (Ricketts No. 10.) Cut through left body wall up to edge of the parapodia, releasing much fluid, relieving the distension of the body.

The low margins of the parapodia extend backward for a distance of 23 mm. before the main pallial (parapodial) chamber opens, the floor of the shallow space between them being occupied by the median spermatic furrow. At the hinder end of the space the (inter-) parapodial cavity suddenly widens, passing downward on the left nearly to opposite the approximate foot margin behind, well below the union of the parapodia, and beneath the posterior end of the visceral mass, a condition approaching that of *Notarchus*.

The margins of the parapodia fit so close together that the pallial cavity may be closed by their approximation as far back as the posterior end of the slit which is dilated into a round aperture with reflexed, thin, prominent margin.

The right mantle margin projects broadly above the gill which is much contracted. The yellowish edge, followed by a broad submarginal zone of purplish black, passes over centrally into irregularly scattered spots and blotches of the same color.

*Mantle foramen* large, elongate, oval, its edges very thin, exposing the yellowish shell below. Opening 27.2 mm. long by 7.8 mm. broad at widest place, nearly as long as the shell. Margin behind continuous into a prominent inrolled siphon inclosed in front by the shell sinus, finely speckled with brown, its edges thin and undulating.

Hinder margin of *siphon* continued downward and forward as a whitish thick

ridge in the floor of the mantle cavity. Outer wall of this cavity, a large thick glandular mass of short colorless tubercles opening diffusely at the surface of the side and floor of the cavity.

The anterior insertion of the parapodia is 26.6 mm. in front of the anterior margin of the mantle, the parapodial edges fitting close together above the median groove in the floor of which is the spermatic furrow. The inner lower margin of the left parapodium is continued into the anterior margin of the mantle, leaving an opening downward and backward into the gill chamber; above the mantle, the inner parapodial space abruptly dilates into a large cavity, extending downward on the left to the level of the foot. It is prolonged behind and below the rounded end of the visceral mass which projects into it in the same manner as in *Notarchus*, but it is not so fully surrounded by it as in that genus. Distance from above anterior margin of mantle to posterior wall of hinder foramen 55 mm. Total length of dorsal slit 81 mm. On the left side the mantle merges with the surface of the visceral mass without a trace of a definite boundary.

*Shell.* Upper membranous layer in front detached from the calcareous layer below, which is badly cracked and broken. Its thin margins, in part, dissolved by action of formalin becoming acid. The nuclear region was removed with some difficulty. The cavity, below the mantle and above the gill, extends the full width of the shell to the left side. The color is deep rich brown.

*Gill plume* contracted, crescentic, brown above, the anterior right border becoming light brown; broadly attached on the left side to the wall of the gill chamber; lamellate, of about 12 principal lamellae which are in turn lamellate.

The *osphradium* lies in a small elongate depression at the entrance to the gill chamber below the mantle margin and upon the efferent vessel of the gill as it enters the body wall. The depression is inconspicuously pigmented.

The *spermatic groove* passes downward and backward along the floor of the gill chamber to the opposite middle of the gill below, the conspicuous low fold extending forward from the posterior siphonal margin.

*Radula.* (Pl. 8, figs. 26-28.) The pharyngeal bulb is small in proportion to the size of the animal; 17 mm. long, 15 mm. wide, and 12 mm. high. Somewhat flattened, ovoid, the mouth tube and region are strongly contracted, radula sac not projecting.

Deep brown in the older portions, becoming lighter behind and beneath the sheath. Functional anterior portion convex, oval, with a deep median groove passing downward in the posterior half into that part of the radula beneath the sheath, which forms an incomplete cylinder, open behind vertically. Flattened out, it is rectangular (squarish) behind, pointed in front (anterior one-third). Length 14 mm., width 15 mm. With the tip folded back, there are plus 54 rows, 20 in front of the fold.

In the 28th row, 200 laterals were counted. Each lateral a compressed, nearly erect hook, its tip blunt, squarish; tip of first lateral more pointed. The rachis is very



narrow, occupied by a small, narrow, nearly rudimentary median plate, with no, or a very slight cusp developed, crowded into the narrow groove by the adjacent laterals. (Pl. 8, fig. 26.)

For detailed study, the radula was cut and mounted in glycerine. A lateral from the third row is a simple compressed hook. Vertical height 0.36 mm., base length 0.23 mm. They are straight almost erect hooks, bluntly pointed except the first lateral on each side of the median. (Pl. 8, fig. 27.) The outermost (pl. 8, fig. 28) two-thirds of the laterals have the same shape as the others, but decreasing somewhat in size, the others nearly uniform throughout the row. One hundred ninety-eight teeth were counted in the 25th row, ranging up to 210 laterals in the youngest rows. The radula formula for *Dolabella californica* is 54 (198-210.1.198-210); for *Dolabella agassizii* it is 62 (198-230.1.198-230). (MacFarland, 1918.)

*Mandibles.* (Ricketts, specimen No. 10.) The lining of the mouth and bulb was isolated. The lips are covered with a strong pale-brown cuticula. The mandibles are pale yellow. Mandible length 4 mm., maximum width 1.5 mm. The rodlets are prismatic in form, the prisms are slender, about 0.012 mm. in diameter. (Pl. 8, figs. 29, 30, 31.)

*Palatal plates.* (Ricketts, No. 10.) The roof of the mouth continues backward as a deep furrow, passing dorso-laterally into the long palatal plates in front and lateral to the oesophageal opening. These are densely set with tapering palatal spines, brown in color, the two plates separate above. (Pl. 8, fig. 32.)

The plates are long, narrow, strap-like. Spinous portion 15 mm. long by 3.5 mm. wide. The spines are elongate, tapering to a blunt curved tip, directed obliquely backward, of varying sizes intermingled, the hinder face has a longitudinal groove, wide and deep at the base, narrowing and shallower upward toward the tip. The groove on the posterior face, in some thicker spines, approaches a flattening of the surface with but slight marginal elevations. As seen in sections this is slight or absent. Each spine is made up of layers of chitin and is apparently hollow with irregular partitions at intervals across it. Random spines, somewhat obliquely seen, measure in length .120, .195, .360 mm. Basal diameter .09 mm. to .12 mm.

*Liver* very dark in color. In close contact, on its right and rear surfaces, is the large, yellowish, compact *ovotestis*. Above it, in close contact with the wall of the gill chamber, is the adnexed genital mass.

From the upper face of the ovotestis, the tortuous, short, small *hermaphroditic duct* arises by the union of tributary ducts from the lobes of the ovotestis. Its convolutions lie between the ovotestis and the anterior genital mass.

The *adnexed genital mass* lying in a latero-ventral position is somewhat hemispherical, its inner surface flattened against the liver lobes; its outer surface against the body wall. The glandular spirals of the mucous portion crumble at the touch so that the

exact form of the gland complex is not clear. Length of mass on dorsal face about 36.7 mm.

The large *hermaphroditic duct* arises from the anterior right border of the mass, describes an irregular loop to the right, with a total length of approximately 100 mm., returning to the genital opening in the integument almost directly above its origin. Diameter, at about this point, 4.5 mm. Midway of its length it becomes twisted into a close spiral of some three turns. At a distance of about 15 mm. from the opening, the duct dilates somewhat, forming an elbow, the *bursa copulatrix*. From this a thick-walled duct passes (cut from the remainder in removing the mass from the animal), probably the duct of the spermatheca.

Upon the opposite face of the adnexed genital mass, the *small hermaphroditic duct*, which has approached the hinder left border of the anterior genital mass, appears imbedded in a groove upon the blue-black gland; or possibly it crosses the origin of the large hermaphroditic duct and passes diagonally across the albumen gland to the opposite margin. It then curves around it to the dorsal face, describes a large loop upon it in the black surface of the nidamental gland, returns to the margin, and recurves around it to the ventral face of the mass and passes across it to the *fertilization chamber* into which it opens.

The *spermatocyst* is a thick tube looped upon itself.

*Penis* dissected out. The great contraction of the head region probably alters its normal position. Retractors inserted below the bulb on the opposite side, in front of the present position of the external opening.

Penis sac bent in close loop, its upper distal limit about .22 mm. long, its lower, proximal limb .36 mm. long, including part of retractor muscle.

*Verge* contracted to less than half the full length of the penis sheath, the spermatic groove continued along its inner face to the bluntly pointed tip. (Pl. 9, fig. 14.) No armature. Lower margin of the furrow expanded as a prominent flattened ridge.

On the opposite side of the verge there is a very broad wing-like expansion, arising near the base of the verge and continuing distally to near the tip. (Pl. 9, fig. 13.)

At its base the verge is elliptical in section with the spermatic furrow as a distinct groove upon its inner face. Distally it becomes flattened somewhat, the dorso-exterior margin (of the outer face) is produced into a wide expansion inrolled over the external longitudinal groove, which extends nearly to the tip. On the margin of the lower face it is thicker, the spermatic groove narrower and deeper. (Pl. 9, figs. 13, 14.) Linear cross sections are represented; figure 13, *b-b*; figure 14, *a-a*. These figures clarify the form of the verge and its spermatic groove.\*

\**Note.* It is obvious that the author had not finished the anatomical work on *Dolabella californica*. (O. H. MacF.)

## DESCRIPTION OF SPECIMEN 26.

Collected by Ricketts April 2, 1940. "San Gabriel Bay, Espíritu Santo Island, tectibranch presumably from beach of coral sand." The animal, similar to the larger No. 10, but this one is notably green spotted.

*External characters.* Length, 85 mm., maximum width 48 mm., height 31 mm., circumference at anterior edge of truncation 130 mm., circumference of posterior disk, 132 mm.

*Body* a depressed cone tapering forward uniformly from margin of hind disk.

*Head* region somewhat contracted, narrower than the body.

*Rhinophores* contracted, flaccid, cylindrical; slit downward from the tip one-half their length, bases 1.4 mm. apart, 4 mm. back of frontal margin.

*Anterior tentacles* much contracted, auriculate, tips rounded, not continued to mouth margin.

*Foot* smooth, lateral edges continuous with sides of body. Front margin continuous with neck region with no perceptible margin or groove, posterior end broad, no tail, a conspicuous wide median notch present.

*Eye* deep in the integument in front of outer edge of rhinophore base.

*Posterior disk* elliptical, nearly circular, 47 mm. wide and 38 mm. high, bounded by a thin prominent marginal wall, nearly continuous above with the margins of the parapodia. The surface of the disk is beset with numerous low wart-like tubercles; the dorsal and lateral surfaces are rough with low rounded tubercles everywhere. These tubercles are dark green in color. Dorsum of head with a few good-sized low tubercles, a single median one between the hinder part of the tentacles.

*Parapodial edges* thick, smooth, in front separated by the genital furrow only, behind fused, forming a slightly dilated rounded opening through which the rolled siphon margin of the mantle is visible. Dorsal slit between the parapodial edges 35 mm., its greatest width 4 mm. opposite upper margin of posterior disk; anterior end of slit 29 mm. behind the mid-base of rhinophores, 37 mm. behind the frontal margin of the head.

*Spermatic furrow* distinct, passing into the penial opening below and just behind the right tentacle. Mouth a vertical slit.

## Order SACOGLOSSA

### Family STILIGERIDAE

#### Genus *Hermaea* LOVÉN

*Hermaea* LOVÉN. 1844. Öfvers. Vetensk. Akad. Förh., Stockholm, vol. 1, no. 3, p. 50. Genotype, *Doris bifida* Montagu, 1815.

#### *Hermaea ornata* MacFarland, new species

Plate 4, figure 3; plate 10, figures 1-5; plate 30, figures 11, 12

#### LIVING SPECIMEN.

*Body* aeolidiform, rounded above, slightly depressed, broadest in the cardiac region, tapering behind to the tip of a flattened, pointed tail which is almost one-third the total length of the animal.

*Foot* narrower than the body, its lateral margins rather wide and thin, well set off from the sides of the body. The anterior end thickened and rounded, but slightly emarginate in the mid-line.

*Tail* long, flat, and wide, forming a feature of prominence.

The *back* with a prominent, oval cardiac area extending in front as far as the most anterior cerata, and sloping downward into the convex head region. Behind, the cardiac hillock terminates abruptly, the nearly flat back continues into the tail.

*Head* bluntly rounded in front and bearing two long auriculate rhinophores with slightly expanded bases. The external face is canaliculate throughout its entire length, forming a deep groove. The margins of this are of equal length and meet above in a tapering blunt tip; the posterior margin dies away on the side of the head, while the anterior one is prolonged laterally downward and forward around the lower margin of the head. Here it unites with its mate of the opposite side, forming a prominent subvelar margin, beneath which, in the median line, is the slit-like mouth opening.

The *eyes*, immediately behind the rhinophores, show through the integument as small black spots surrounded by clear areas.

The *cerata* are borne on the lateral margins of the dorsum, arranged in short closely set oblique rows some three to five in each, in which, however, the irregularity of insertion may almost conceal the individual rows. In general the shortest cerata are outermost, the longer within; however they are intermingled toward the median area which is free from them throughout the entire length. Toward the posterior of the dorsum, the rows approach as the space narrows, forming an abrupt transition to the level of the flattened tail. The individual cerata vary greatly in size, narrowed at the base, tapered to pointed tips. Following the liver branches as they enter the cerata, there are smaller branches, probably from the albumen gland.

The *anal opening* is at the summit of a prominent cylindrical papilla immediately in front of the cardiac elevation and arching over it in the median line: just back of this papilla is the inconspicuous renal pore.

*Reproductive openings* on the right side are, at least, two. The male opening is on a prominent rounded papilla below and behind the eye. On the right side, close below the rhinophore and extending back 2 mm. below the center of the side, is a conspicuous narrow ridge-like elevation caused by the presence, below the integument, of the cylindrical receptaculum seminis. Just in front of, and below its anterior end, is the female opening, the vulva.

Three specimens show two reproductive openings clearly, but no trace of a third upon the ridge of the receptaculum seminis, which itself is very prominent. Probably this could be shown by perfect serial sections. The duct of the receptaculum seminis does not open by a third aperture as figured by Pelseneer, the "orifice vaginal" of figure D, 1894, page 55.

No trace of *mandibles* was found. The *radula* is very small, not over 0.525 mm. in total length in a large specimen. It is uniserial, consisting of some forty-five teeth, the oldest and smallest being coiled in a sac or ascus at the anterior end. Six of these oldest teeth consist of the cuboidal bases alone, the seventh bears a short spine, the remainder increase regularly in size to the matrix in the sheath. Thirty-six teeth were found in the lower part of the radula to its anterior angle and nine more from that point to the youngest, a total of forty-five in all. The sac containing the oldest teeth is almost directly beneath and slightly behind the youngest, the whole radula forming an approximate incomplete-oval, the angle in front being marked by a greater separation of the cusps. (Pl. 10, figs. 1-3.)

Each tooth consists of a cuboidal base from which arises, at an angle of about 25°, a straight compressed cusp, in profile resembling a stout pocket-knife blade. The posterior edge of this cusp is thin and narrow, the tip pointed. The anterior margin is thickened and bears a wide longitudinal V-shaped groove beginning at the anterior lower end of the base where it is flanked by two rounded prolongations of its sides and extends nearly the whole length of the blade. (Pl. 10, fig. 4.) Into this groove the posterior edge of the preceding tooth closely fits, and remains in that position in all except the teeth actually in use at the angle. The length of the base of the oldest tooth, in a preserved specimen of 9.0 mm. total length, was 0.008 mm. The base of the thirty-sixth tooth, at the angle, was 0.027 mm., increasing but slightly beyond. The length of the cusp from the tip to the basal end of the sides of the anterior groove is 0.065 mm. in the thirty-ninth tooth and increases to 0.09 mm.

The *ventral surface* of the base bears a deep and broad groove. Owing to the shape of the tooth an end view is not easily obtained, but is readily found in serial sections. (Pl. 10, fig. 2.) The width of the base of a tooth close to the angle of the radula is 0.021 mm., the height of the base 0.024 mm., the depth of the basal groove 0.007 mm. These measurements are approximations, of course, on account of the ob-

liquity of the sections and will vary in specimens of different sizes. These were taken from a specimen 9.5 mm. long, cut in transverse series.

In cross section the tooth is V-shaped, the anterior groove forming an angle of about  $65^{\circ}$  as shown in figure 5 of plate 10 in which, however, the plane of the section is slightly oblique to the long axis of the tooth.

Basal length of outline of radula <i>in situ</i>	0.27 mm.
Basal height of outline of radula <i>in situ</i>	0.18 mm.
Length of outline of radula <i>in situ</i> to extreme end of cusps	0.318 mm.
Height of outline of radula <i>in situ</i> to extreme end of cusps	0.228 mm.
Length of base of first, oldest tooth (pl. 10, fig. 3)	0.008 mm.
Length of base of thirty-sixth (at angle, pl. 10, fig. 1)	0.027 mm.
Vertical height of thirty-sixth	0.045 mm.

*Color*, living specimen. (Pl. 4, fig. 3.) The general ground color of the animal is a pale cadmium yellow. The dorsal surface is ornamented by an arborescent system of light olive green to dark green (hooker's) bands below the integument, the branchings of the liver. These branches vary in width and in extent in different specimens, making the animal appear lighter or darker in color as a result of their development and the depth of the green pigmentation. The general plan of their distribution, however, is the same. From beneath the anterior part of the cardiac elevation on either side appears a main anterior liver branch. That of the right side sends off subdivisions to the anterior cerata and a central branch which recurves and passes up the anal tube, ramifying on it. The main stem passes forward and breaks up into an extensive arborescence upon the median dorsum and the right side of the head, sending rami to both rhinophores which pass along the inner faces extending well out toward their tips. A median branch ramifies over the entire front of the head.

The left anterior liver trunk sends rami to the left anterior cerata and to the left lateral area between them and the rhinophore. Only in exceptional cases do the subdivisions from the left trunk reach the central region of the head, the left rhinophore or the anal tube, and only then through anastomosing branches with those of the right side, which usually are alone distributed to those areas.

From below the middle of the posterior border of the cardiac elevation appears a strong liver branch which subdivides at once into a right and left posterior branch passing backward, parallel to each other, to the tip of the tail. These posterior trunks give off external, lateral branches to the cerata of either side, each forming elongated meshes through anastomoses of its own branches but leaving the median portion free until the tail is reached.

Here, while the central portion may remain free, short branches are given off toward the margin of the tail from the main lateral trunks which may anastomose in a rich network covering the mid area. The tip of the tail is left free of separate branches.



The large liver trunk to each ceras occupies an axial portion and from it a multitude of finer lateral branches arise which fork and ramify toward the surface, terminating in slightly thickened, rounded ends. The distal half of the rhinophore is usually free from liver branchings, and is clear yellowish white as are also the sole of the foot, the sides of the body below the rhinophores, the dorsal surface of the cardiac eminence, and all other portions not reached by the hepatic branches.

In the preserved material the green color is soon dissolved out by the alcohol and the animal becomes uniformly gray in hue. No medium has been found which completely preserves the color.

*Dimensions.* May 3, 1926, many specimens taken on *Bryopsis* at Park's Point, -.9 tide. Length was from 15.6 mm. to the smallest of 6 mm.

A large specimen had the following measurements while living:

Length	14.0 mm.
Width of tail near cerata	2.0 mm.
Width of foot, anterior end	2.8 mm.
Width of body between cerata, cardiac region	2.0 mm.
Length of rhinophore	2.8 mm.
Length of longest ceras	6.0 mm.
Anal papilla	$\frac{1}{4}$ to $\frac{1}{3}$ height of rhinophore

*Two mature living specimens:*

Length	8.7 mm.
Width	2.3 mm.
Cerata length	3.5 mm.
Cerata width	0.5 mm.
Maximum width below foot when crawling	3.0 mm.

*Alcoholic specimen:*

Frontal margin to end of cerata groups	7.0 mm.		
Tapering tail 2.7 + 1.6	<u>4.3 mm.</u>		
Total length	11.3 mm.		
Maximum width, foot	2.5 mm.	Longest ceras	3.7 mm.
Rhinophore length	2.0 mm.	Diameter ceras	0.6 mm.
Anal papilla	0.5 mm.		

*Habitat.* Taken from Monterey Bay, from Point Pinos south to the entrance of Carmel Bay. Found in the outer tide pools feeding upon *Bryopsis*, rarely upon *Codium*. The first specimen taken on July 20, 1898, at Park's Point: "...green aeolid at the entrance of Carmel Bay from a pool on *Bryopsis*, total length, extended, 8 mm., width of body 2.5 mm." Most abundant at Pescadero Point just north of Pebble Beach.

According to Dr. Gilbert Smith, *Bryopsis corticulans* was almost invariably fruiting in April and vegetative forms were rare. A number of unusually large specimens taken at .9 tide in 1926; another collection was made in 1933; both from *Bryopsis*. The large ones came from Pescadero Point. The others were from Point Pinos, the Large Tide Pool. On *Codium* at Cypress Point were found two very small specimens in 1934.

*Nidosomes* were found in the aquarium after the collection in 1933. Eggs were laid each in a single capsule arranged in parallel rows, transverse to the long, gelatinous, slightly flattened band. This was coiled in a spiral of one and one-third turns, when attached to a flat surface, otherwise irregularly arranged, 1 mm. in diameter.

*Reproductive system.* (From a study of serial sections.)

The *hermaphroditic duct* passes forward from the ovotestis and bifurcates, close to the hermaphroditic ampulla, into the oviduct and vas deferens. This at once receives the duct of the lobulated prostate gland which lies below the anterior end of the closely coiled ampulla. Beyond the prostate, the vas deferens continues outward to the prepuce. The male opening is on a prominent rounded papilla below and behind the eye.

*The glans penis*, 50 $\mu$  series cross sections, A, 1/6 - 6/6 slide 2/6. Tip of the glans bears a short, tapering, curved, protruding stylet, 15 $\mu$  in diameter at its distal end and 18 $\mu$  at its proximal one. The lumen dilates at the base of the glans to 72 $\mu$  and then contracts to 12 $\mu$  through the first muscular portion of the vas deferens. The cuboidal epithelium is 9 $\mu$  in height and in the dilated portion bears very long cilia, about 24 $\mu$  in length. There are faint traces of cuticular structures around the exit of the stylet from its aperture. The section does not show whether they are above or below the epithelium.

The length of the penis from the base of dilation of its lumen to the tip is about .324 mm. which is not an exact measurement owing to the curvature. It has a strong covering of circular muscle cells surrounding the epithelium, and on surface view, resembles an elongated epithelium in its contracted state.

*Receptaculum seminis* appears on slide 2/6, third row, and disappears on slide 4/6, row 3, section 8, a total of 52 sections or approximately 2.6 mm. in length. It is a long tube on the right side close below the surface, behind the opening of the oviduct. It divides into two parallel tubes.

The upper one ends blindly, the lower one is close to the foot and disappears. An external opening was not found. The relations and connections are not clear in the series.

*Vagina.* This opens into the external channel close to the opening of the genital glands and slightly above it. It passes inward, upward, and backward in a short course, connecting with the duct from the large spermatheca, a spherical body.

The vaginal duct continues backward in a median plane, joining the hermaphroditic duct just in front of the ampulla at the point where this duct has bifurcated into the oviduct and vas deferens.



Genus *Hermæina* TRINCHESE

*Hermæina* TRINCHESE, 1874. Mem. Acad. Sci. Bologna, ser. 3, vol. 5, p. 73. Genotype, *Hermæina maculosa* Trinchese.

*Hermæina oliviae* MacFarland, new species

Plate 4, figures 4, 5; plate 10, figures 6-11

## LIVING SPECIMEN.

*Body* slender, graceful, not compressed or depressed, highest in front of cerata and tapering gently backward to the blunt tip of the long tail.

*Foot* narrow, abruptly widened and rounded in front, the foot margin but slightly set off from the sides of the body by a shallow depression. Anterior margin with rounded angles.

The anterior *head* margin is formed by two, well developed, rounded, velar lobes separated in front by a deep groove or notch in the mid-line, continuing laterally backward below the rhinophore bases. With decreasing prominence they die away a short distance behind them. These thin lobes are very mobile and are kept in constant motion while the animal is crawling, probably functioning as tactile organs.

*Mouth* concealed between the tentacular lobes and the anterior margin of the foot.

*Rhinophores* cylindrical, slightly divergent, their bases moderately separated. Each rhinophore is auriculate, in the form of a rolled plate, the anterior, outer margin of which is carried around laterally backward, overlapping somewhat the posterior one. Midway of its length the anterior margin is abruptly narrowed, leaving a step-like projection. This is continued above, meeting the hinder margin in a rounded in-rolled tip, open auriculate, its concavity directed forward more than the remainder of the rhinophore.

*Cerata* in about ten closely set, transverse rows along the prominent dorso-lateral margin of the body, leaving a narrow median area free in front, but obliterated behind. The transverse rows contain three to five inflated cerata on each side, spindle-shaped with pointed tips, and slightly flattened antero-posteriorly, the largest near the median line, the remainder decreasing regularly in size toward the outside, all directed obliquely upward and backward when undisturbed, and not readily dehiscent. The axis of each ceras is occupied by a sinuous branch of the liver from which numerous short, lateral branches are given off at right angles, terminating in blunt ends.

*Eyes* large, black, very conspicuous behind the bases of the rhinophores. Optic nerve unpigmented.

*Reproductive openings* far forward below the base of the right rhinophore. No lateral elevation indicating the presence of a receptaculum seminis, such as in *Hermæa*, was found here.

*Anus* dorso-median at the summit of a low, cylindrical papilla immediately in front of the low cardiac elevation.

*Color.* (Pl. 4, figs. 4, 5.) General color of the body a pale lemon yellow. The stalks of rhinophores a soft light brown in the lower two-thirds, the outer third a light yellow, deepened at the tip, all sprinkled with minute opaque dots of the same color giving an encrusted appearance. Frontal lobes a light brown (burnt sienna), the color being continued laterally as a band of indian red (mahogany). This lateral band bifurcates just behind the base of the rhinophores, the upper division passing backward along the dorso-lateral line to the first group of cerata, where it becomes irregular and sends a prolongation across the back to join its fellow of the opposite side. The lower branch passes backward along the side of the body below the cerata, sending off short, irregular branches, narrowing and finally fading out toward the tail region.

From the inner face of the bases of the rhinophores a narrow mahogany line passes inward and forward, the two uniting in the median line of the top of the head. The triangular area thus delimited on the dorsal surface of the head and neck is light lemon yellow, thickly sprinkled with opaque deep lemon-yellow spots. Lateral to this median triangular area is another of similar color on either side, bounded in front by the rhinophore bases and the burnt sienna of the frontal region, below by the dorso-lateral band of mahogany red, and behind by its transverse prolongation in front of the cerata.

Conspicuous in this area on the sides are the large, black eyes, showing through the transparent integument behind the rhinophore bases. Just behind and below the eyes is a median rounded spot of eosin pink, very brilliant, showing through the integument.

The cerata are a bright, pale, burnt sienna; integument transparent, showing the axial liver stalks, a deepened brown. Cerata tips a lemon yellow, with pointed ends. The surfaces sprinkled everywhere with minute points of pigment, white and yellow.

Along the mid-dorsal area, behind the heart, are small irregular blotches of dark brown as the liver enters each ceras. The large sinuous axial branches send off numerous short lateral ones terminating in blunt ends clearly seen through the integument.

The tail is entirely a pale mahogany. The sole of the foot shows irregular brown mottlings, absent at the anterior end.

*Pharyngeal bulb* small, 0.8 mm. long, 0.6 mm. high and 0.4 mm. in width, its dorsal surface bearing a high, muscular, dome-like prominence. Mandibles are lacking. The colorless radula measures 0.73 mm. of which 0.3 mm. is included in the length from the angle to the end of the sheath.

*Radula* (pl. 10, figs. 6-11) uniserial, small and narrow, the anterior end containing the oldest teeth forming a continuous coil in a pocket-like sac, characteristic of the *Sacoglossa*. In this sac are five small rudimentary teeth, in the ventral limb of the radula twenty-five at angle one, in the dorsal limb beneath the sheath five, and at the posterior end three incomplete teeth may be seen in the matrix, a total of thirty-nine in

all. A typical tooth near the angle of the radula consists of a relatively small, flattened base from which arises a much compressed blade-like cusp which is inclined backward at an angle of about  $250^{\circ}$ . (Pl. 10, fig. 8.)

The anterior end of the base bears a deep vertical notch which is prolonged upward as a longitudinal groove in the anterior face of the cusp. (Pl. 10, fig. 9.) The walls of the groove are thin, their margins are smooth, and the bottom of the groove approaches and reaches the surface at about the outer third of the cusp. The posterior face of the cusp bears a longitudinal, median, smooth, blade-like cutting lamina. On either side of this lamina the posterior surface is continued outward and backward to a clearly defined denticulate margin which extends the full length of the cusp. (Pl. 10, fig. 10.) Through its lower third the denticles are coalesced in many of the teeth into a serrulate ridge; above this region the denticles become separate and distinct, until toward the tip of the cusp they become obscure and disappear, the margin meeting its fellow on the opposite side above the end of the median cutting lamina of the cusp which projects slightly behind it. (Pl. 10, fig. 7.)

Thirty to forty-five denticles may be counted on the youngest teeth. In the older part of the radula in which the teeth are close together, rather than erect and separated as at the angle, the posterior median lamina fits down into the groove upon the anterior face of the surrounding tooth, while the serrulate lateral margin does not do so, but remains opposite the margin of anterior groove wall. The lower, rounded end of the anterior groove wall fits into a curved depression just below the end of the denticulate margin of the preceding tooth.

The length of the cusp of the tooth at the angle of the radula is 0.055 mm., the length of the base is 0.022 mm. The total length of the tooth at the angle, measured from the lower anterior end of the base to the tip of the cusp is 0.077 mm. The angle made by the cusp with the base is approximately  $25^{\circ}$  through the greater part of the radula.

The oldest teeth are all coiled in a sac below the anterior end of the radula. These consist, at first, of a cuboidal base along a pointed projection from its posterior dorsal margin and the first indication of a cusp appears in the second tooth. It rapidly lengthens in the succeeding ones and a slight depression appears in the antero-dorsal surface of the following tooth overlapped by the cusp. The marginal denticulations can be made out in the twelfth tooth, though the close approximation of the radula elements may conceal its presence in younger ones. Throughout the radula the teeth increase steadily in size, at first more rapidly.

*Dimensions* of living animals. Large specimen, floating or crawling, 11.4 mm. long, foot 10.8 mm. in length, average width of foot, 1.1 mm., width at anterior end 1.5 mm., length of rhinophores 1.6 mm., maximum length of cerata, 2.7 mm. Smaller specimen, living, 8.5 mm. long.

*Habitat.* Only two specimens of this interesting species have been taken; both from brown kelp at very low tides, in rocky pools of Monterey Bay, the first one at

Cabrillo Point, July 17, 1904, 8.5 mm. long. This one was used for the painting and the detailed description of the external characters. The specimen was lost as a result of the earthquake of 1906.

On September 21, 1918, a second specimen was found at Point Pinos by Olive H. MacFarland. Length of living animal 11.4 mm. All anatomical descriptions are based upon this alcoholic specimen. With radula removed, body strongly bent, and cerata inflated, approximate length is 2.2 mm. to the bend, 2.2 mm. from this point to the last cerata, tail 1.1 mm., total length 5.5 mm.

### Genus *Phyllobranchopsis* ELIOT

*Phyllobranchopsis* ELIOT, 1905. Journ. Malacol., vol. 12, pp. 52-53. Genotype, *Phyllobranchopsis enteromorpha* Cockerell and Eliot.

### *Phyllobranchopsis enteromorpha* Cockerell and Eliot

Plate 10, figures 16-28

*Phyllobranchopsis enteromorpha* COCKERELL and ELIOT. 1905. Journ. Malacol., vol. 12, pp. 52-53, pl. 8, figs. 20-22.

#### DESCRIPTION OF EXTERNAL FEATURES OF THE LIVING ANIMAL

*Body* not compressed nor depressed, moderately broad, in general very similar to *Hermaca* and *Hermacina*, but with no conspicuous cardiac elevation.

*Foot* narrow, concealed from above, the tail moderately short and pointed. Its frontal margin rounded and thickened with a distinct median notch.

*Frontal veil* notched in median line, laterally prolonged into two rounded lobes which are kept in active tactile movement in crawling. The margins of these lobes continued up into the anterior margin of the rhinophore groove. The mouth is concealed under the labial palps.

*Back* uniformly arched, the cardiac elevation not at all prominent, free from cerata bases which are borne well down on the dorsal margin. Just behind the rhinophores the two series approach each other but a space is left free. Posteriorly the cerata approach at the base of the tail, but do not meet.

*Rhinophores* auriculate, similar to those of *Hermacina*, consisting of a rolled plate forming an external groove. The anterior margin of this is abruptly narrowed about midway of its length, forming a step-like interruption, the distal half is narrowed with a rounded tip directed somewhat forward (not pointed as in *Hermaca*).

*Eyes* conspicuous, black, close behind the rhinophores.

*Cerata* in about three irregular longitudinal series on the lateral margins of the body, spindle-shaped, conical, slightly flattened antero-posteriorly (but not leaf-like). The largest cerata are broadest about midway of their height and are three times as high as broad.

*Anal opening* at the summit of a very low, inconspicuous elevation, at the right of the mid-line of the notum, slightly behind the level of the first ceras on the right side.

*Reproductive openings* two, close together below and immediately behind the right rhinophore base.

*Color* in life of the Monterey specimens was similar to that described by Cockerell for the four specimens taken by him. Those taken in Elkhorn Slough were greenish white with irregular, very dark markings upon the sides, head, tail, and rhinophores; also sparsely on the foot. The notum and sides showed mottled spots of very dark green, the general color being much darker than that of any representative *Hermaea* collected. The sole of the foot uniformly light, edges of labial palps, rhinophore margins, and tail almost white. The general color was not limited to the liver ramifications alone, but to the integumental pigmentations as well. The dorsum of the head is dark brown, which color continues between and lateral to the rhinophores. These, as well as the frontal lobes, are also brown. The posterior surface of the rhinophores expands toward the mid-line of the head into a rounded area in the center of which is the small black eye. The general color of the cerata is gray, shading into green at the tips which are white. In some specimens the cerata are almost colorless; the axial liver processes, showing through the integument, bear short, blunt, lateral ends flattened below the surface. At the base, each central process continues with the lateral dorsal canal of irregular outline.

In preserved material, the notum, head, and sides of the body may be almost entirely green to black, or mottled to a less degree. The cerata become uniformly gray. The white lines on the margins of the head parts and tail persist.

The pigment is a very dark green; nearly black granules are found in the epithelium cells everywhere on the body and cerata persisting in alcoholic material for years. Similar granules occur in the lining cells of the mucous glands, scattered masses in the peripheral wall of the ovotestis acini, and in the central nervous system ganglia.

No pigment is preserved in the liver branches found in serial sections. Cerata pressed under a cover glass in weak potassium hydroxide show an abundance of finely granular cells, .72 mm. maximum diameter. These are toward the tips, while below the epithelium are straight needle-like spicules, .192 mm. by .006 mm. scattered in clumps.

*Radula.* Two mounts of the whole were used in the study of the teeth supplemented by serial sections cut in various planes. The radula is uniserial; the anterior

end contains the oldest teeth, forming a continuous coil in a pocket-like sac. In this sac are five small rudimentary teeth. (Pl. 10, fig. 20.) From the fifth tooth the base lengthens, and the smooth median ridge develops with the two denticulate laminae, including between them a median wedge-shaped space. Length of the base of the oldest tooth, .005 mm.

The ventral limb of the radula extends beyond the sac with twenty-eight mature teeth, six are found beyond the angle in the dorsal limb, making a total of thirty-four teeth.

Measurements of the second tooth (pl. 10, fig. 19), length over all, .096 mm.; length of base, .036 mm. From the apex to the inner angle at the base of the tooth, .066 mm. The length of the base is greater than the width and has on the under surface a groove, partly here concealed. In some cases the lateral surface of the base is roughened as in figure 19.

The similarity of the radulae as seen in side view is most striking, but the interpretation of tooth form by Eliot is widely different from mine. He seems to have had but one view of the teeth, the lateral one, and bases his ideas upon it alone. But such an object must be studied in each of its three dimensions, and that I have accomplished by the use of serial sections after celloidin embedding.

Eliot described the tooth as having a deep indentation in the back and a spoon-shaped cavity at the (apical) end, across which runs longitudinally a thin lamina bearing a row of numerous fine denticles. Such an appearance seems true of the Monterey specimen, but a closer study with accurate focusing upon whole mounts, and comparison with sections in various planes, shows clearly that the "deep indentation on the back" represents the upper end of a thinner median ridge borne upon the lower part of the back or anterior face of the tooth. The distal end has no spoon-shaped cavity upon its posterior face, but is flattened from side to side so that its rounded apex, so far from presenting a vaulted surface, is in fact a thin cutting edge. The median denticulate lamina is not single, but double, two thin laminae projecting backward at a slightly divergent angle and including between them (pl. 10, fig. 21) a median wedge-shaped space into which the anterior median lamina of the following tooth fits when the teeth are in approximation.

Trinchese evidently has fallen into the same error in his figures of the radula of *Hermaeina maculosa*. I have no doubt but that a close study of this species will show that it, too, has two denticulate laminae upon the posterior face of each tooth. No one seems to have verified his statements since then, nor to have applied the method of serial sections to these radulae, without which a frontal view of such a tooth is very difficult to obtain.

Plate 10, figure 21 shows a series of drawings which clarify the foregoing descriptions of the radulae under discussion. A perfect series of 112 sections was used, counter stained with alizarin to differentiate the parts.

Figures of the ventral limb are indicated as *a*, *b*, *c*, *e*; those of the dorsal limb, as *a'*, *b'*, *c'*, *e'*. A detailed explanation is given for each figure.



*Dimensions.* Alcoholic specimens

## Large specimen:

Length . . . . .	6.0 mm.
Width. . . . .	2.05 mm.
Foot width . . . . .	2.0 mm.
Rhinophore length. . .	1.05 mm.
Width. . . . .	0.05 mm. at notch
Large cerata length . .	3.0 mm.
Width. . . . .	1.5 mm.

## Small specimen:

Length . . . . .	5.0 mm.
Width. . . . .	2.0 mm.
Large cerata length . .	2.0 mm.
Width. . . . .	1.0 mm.

*Habitat.* Elkhorn Slough, Monterey Bay, July 13, 1941, on *Enteromorpha*; Miss Betty Blagg, collector.

## EXTENDED ANATOMICAL DESCRIPTION

*Glands.* These were studied in celloidin sections,  $40\mu$  thick. The epidermis is filled with dark brown pigment granules. At the entrance of the pharyngeal bulb on each side is a group of large branching alveolar glands with a duct entering from the gland alveoli.

There is a small lobulated gland upon and around the stomach and oesophagus; its slender paired duct passes forward below the oesophagus and through the nerve ring to open into the pharyngeal bulb on each side.

The anterior margin of the foot is packed with alveolar glands, each with a slender duct.

The epithelium of the cerata has many deeply staining unicellular glands lying below the epithelium and connected with the surface by slender duct-like prolongations. No branches of the reproductive glands enter the cerata, the liver branches alone enter them.

Pigment is found in dense layers of the epithelium of the foot and in the outer surface of the ovotestis lobules. In the mucous gland of the reproductive system occurs a dark band on the outer surfaces; pigment is scattered also in the periphery of the central nervous system ganglia.

*Reproductive system.* This was studied in the celloidin sagittal sections. (Pl. 10, figs. 26, 27, 28.)

The relations of the large spherical sac (spermatheca) to its duct and to the vagina is correct as shown. The sac is not a crop. Neither is it an oesophageal diverticulum or the stomach. It contained a coagulum in which sperm heads were made out. In the duct are coagulated axial strands of sperm. The wall of the spermatheca is



strong, having an outer muscular layer and lining of cuboidal epithelium bearing low cilia matted together in tufts. The thickness of the sections ( $30\mu$ ) makes details obscure.

Figure 27 is a diagrammatical drawing to show the connections of the vagina and its ducts. Close beyond its opening, the vagina receives the short duct of the elongate, nearly vertical, spermatocyst lying close behind, and in contact with the spermatheca. It is a long tubular sac crowded with sperm. It is about 0.8 mm. long by 0.07 mm. in diameter; it is lined by high columnar ciliated epithelium with basal, deeply staining nuclei resting upon a thin outer coat of connective tissue. (Pl. 10. fig. 28.) Opposite the opening of the spermatocyst duct the vagina wall begins to show closely set alveoli of mucous cells outside of its proper, low, cuboidal epithelium. It opens into the right ventro-posterior lobe of the mucous gland.

The alveoli of the prostate gland are short, simple spherical branches from the main duct and its short subdivisions. The cells of the alveoli have large nuclei rich in chromatin; the ducts have high cuboidal cells containing small nuclei.

## Family ELYSIIDAE

### Genus *Elysia* Risso

*Elysia* RISSO. 1818. Journ. de Phys., vol. 87, p. 375. Genotype, *Elysia timida* Risso, 1818.

### *Elysia bedeckta* MacFarland, new species

Plate 4, figures 1, 2; plate 10, figures 12-15

#### DESCRIPTION OF LIVING SPECIMEN.

*Body.* This is rounded above, with parapodia carried folded together in a vertical position giving the appearance of being much compressed, which they are not. In general form the animal is narrow, elongated, with a pointed posterior and a blunt widened head.

The *head* is rounded and slopes downward anteriorly, between the rhinophores. The anterior margins are rounded, bilobed, and thickened, forming two short tentacles.

The *foot* has a thickened anterior margin, dilated somewhat and kept in constant motion in a peculiar lip-like manner against the lower portion of the head. Throughout the foot is narrow, projecting beyond the sides of the body with no indication of a boundary.

The *tail* is bluntly rounded into the slightly narrowed tip. A transverse narrow groove divides the foot anteriorly into two regions. This curves slightly posteriorly and is continued upward laterally to the anterior ends of the parapodia.

The *rhinophores* are short, conical, erect, slightly divergent, with a wide groove. The edges are inrolled, auriform at the tips, almost leaf-like, opening outwardly; they are edged with translucent white.

The *parapodia* are long and triangular in form, highest near the anterior end. They are thick and fleshy with rounded edges, not thinning away, and often thrown into folds. They are usually carried in contact but often separated behind.

The *heart* is a conspicuous bulge on the center of the body between the anterior ends of the parapodia. Midway of this elevation, on the right side, is situated the *anus*.

The *mouth* is rather inconspicuous in a median line in front of the foot margin.

The *eye* is posterior and slightly lateral to the base of the rhinophore. It is very black and pigment present on the optic nerve gives the organ a deep black-stalked form directed inward and backward.

The two *reproductive openings* are close together below and behind the base of the right rhinophore. The male opening is anterior, the female one apparently at the anterior margin of the right parapodium. A slight groove passes backward from the male opening.

In one live specimen the *glans* protruded behind and below the base of the right rhinophore, colorless, conical, broad at the base with a pointed tip.

*Radula.* The *pharyngeal bulb* is of somewhat compressed ovoid outline, its dorsal half semiglobular and strongly muscular, being marked transversely by a series of hoop-like bands, some twenty-six in number. The dorsal portion is set off sharply from the ventral half, the walls of which are thinner and smooth.

A median antero-ventral ridge indicates the position of the anterior end of the radula and behind it a slightly less prominent one is formed by the radula sac.

Length of the bulb 0.45 mm., height behind the radula ridge 0.435 mm. Height of the anterior radula sac to top 0.495 mm.

Bulb in the dorsal view, oval length  $32 \times .015$  - .48 mm. Maximum width  $25 \times .015$  - 0.225 mm.

The radula teeth are of the usual type for *Elysia*. The oldest, at least eight in number, are jumbled together in a loose pile in the sac at the posterior end of the lower limb of the radula. The lower limb has sixteen teeth, regularly arranged, in increasing series, upon the basement membrane. The most anterior of these is just at the angle. (Pl. 10, fig. 14.)

The upper limb contains six teeth and one incomplete in the matrix. The comparative measurements are given at the end of this description.

In general the base ranges from 0.012 mm. in length in the oldest attached tooth, to 0.030 mm. in the youngest (the 22nd). The cusp has a length from its anterior basal projection to the tip, of 0.33 mm. in the oldest to 0.120 in the youngest. The cusp, from its posterior basal insertion, has a length ranging from 0.020 mm. in the oldest to 0.090 mm. in the youngest. The 16th tooth (pl. 10, fig. 12) at the angle has the following measurements: *c-d* basal length .0276 mm., *a-b* total length of cusp from anterior basal projection to its tip .108 mm., *a-e* length of cusp from posterior basal insertion to

the tip .0732 mm., *a-c* oblique height of tooth from posterior angle of base to tip of cusp in a straight line .078 mm. (Pl. 10, fig. 12.) The 19th tooth is the longest of the series; the basal length being .036 mm., the cusp length .168 mm.

*Color.* The color plan of *Elysia bedeckta*, as shown in a living specimen, is most elaborate. Plate 4, figures 1 and 2 show figures which are, at best, a poor representation of the living animal.

The general color appears to be a rich ivy green. Under magnification, however, the body color is a pale cadmium yellow. This is thickly set everywhere with a dark green network, a modified hooker's green.

Between and below the more superficial vascular ridges is an elaborate system of dendritic ramifications. These penetrate under the surface everywhere carrying the green color. The ramifications have terminal endings just under the surface. They appear as sharp points of green or as a thickened anastomosing of the vessels. The moss-like color and texture of *Elysia* are not unlike the *Codium* upon which it is sometimes found.

Over the entire surface is a covering of minute yellow points which make it glow with brilliance. Over this are large sparsely scattered spots of various colors which have a metallic sheen on the dorsum, the sides, and the outer and inner surfaces of the parapodia. Cerulean blue, emerald green, bright red and orange-yellow are found. To represent their brilliance is a task for nature alone.

On the dorsum, in a transverse band in front of the heart, these colors extend across from the base of one parapodium to the opposite one.

Elongated groups of white spots are found at intervals along the thickened edges of the parapodia, on the outside tips of the rhinophores. White is found on the edge of the mouth parts and as a large rounded group of spots on the outside lower edge of the parapodia where they join the side of the body. Scattered fine sprinklings occur on the foot and ventral side, but no colored spots are present.

These markings are constant on all specimens studied. It is difficult to show white spots on the edges and at the same time keep the high lights.

The study of a large specimen preserved in alcohol (which extracts the green color) revealed the following:

The *elevated veins* of the dorsal surface of the wings stand out as white ridges between which the irregular green dendritic markings are still visible. Toward the margins of the wings the finer subdivisions of the veins cease and the green becomes a continuous border about 1 mm. wide.

The main vessels in direct sunlight stand up as distinct rounded ridges between which another system of white dendritic ramifications is seen. The cardiac elevation is green, bordered laterally and behind by a broad zone of white.

The *foot margin* passes uninterruptedly up into the lateral lobes without any line of demarcation, also rounding in front up into the sides of the body.

The two *reproductive openings* are close together below and behind the base of the right rhinophore, not seen higher and behind as indicated by Eliot.

The *anus* is a small round opening on the right anterior side of the pericardial hump.

The Klotz fluid and alcoholic specimen both show clearly a single postero-lateral elevated vessel on either side leading out from the pericardial elevation and sending its ramifications to the greater portion of the lobes.

Two other paired vessels are also found, one from the median side, one from the antero-lateral region of the hillock. The posterior pair are the longest. Each one bifurcates eight or nine times, the branches, in turn, again bifurcating from two to four times. As the marginal zone is approached, the ridges become less and less prominent.

*Cardiac elevation.* This elevation is 3.0 mm. long by 2.0 mm. wide, green-color markings extend backward from the head region leaving a crescentic unpigmented area.

The color of the dorsal region is due to fine dendritic ramifications of narrow lines of color between and below the more superficial vascular ridges.

The color of the median dorsal cardiac area and of the head, rhinophores, and ventral surfaces is due to finer ramifications and free tips coming to the surface from a deeper network. This gives it a general punctate appearance. The dorsal lines lie at different levels so that frequent anastomoses may be seen by focusing up and down.

Deep below the network of the narrower lines is an irregular broader dark-green pattern on the dorsum of the wings, with which the upper network seems to be connected, and from which arise oblique branches to the superficial network. This area is not developed close to the heart. (Pl. 4, figs. 1, 2.)

*Dimensions of live specimens.*

On *Bryopsis*, Pebble Beach - 1902

First specimen:

Length	9.0 mm.
Diameter	1.5 mm.
Parapodia, length	7.0 mm.
Parapodia, height	2.0 mm.

Second specimen, small:

Length	4.0 mm.
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On *Uta*, Moss Beach - June 1921, 1922

Large specimen:

Length	22.0 mm.
Height	8.0 mm.

Second specimen:

Length	13.5 mm.
Height, parapodia	4.7 mm.
Head, parapodia to anterior margin	2.7 mm.

On *Bryopsis*, Park's Point – May 3, 1926

Largest specimen taken:

Length, crawling	29.3 mm.
Height	10.0 mm. to top of parapodia
Head length	2.7 mm. anterior margin to parapodia
Body length	26.6 mm. anterior margin of parapodia to tip of tail
Foot width	3.4 mm. widest point, anterior margin
Transverse groove	4.0 mm. posterior of anterior margin

*Dimensions of alcoholic specimens.*

Large specimen from Point Pinos, 1926

Length over all	21.0 mm.
Lateral expansion	16.0 mm.

Five specimens had lengths of 16, 8, 7, 7 and 4 mm.

*Habitat.* Monterey Bay from Park's Point north as far as Elkhorn Slough. They are found occasionally on *Codium*, *Ulva*, and other kelp, but *Bryopsis* is the food liked best. One fine specimen was taken at Newport Bay on *Codium*, 1946.

A specimen was collected from *Bryopsis* (*corticulans* Setchell?) found on the rocks below Pescadero Point, May 3, 1926, –9 tide. Numerous hermaeas were in the same habitat. Living measurements: length 29.3 mm., height to top of parapodia 10 mm. From anterior edge of parapodia to tip of tail 26.6 mm., length of head 2.7 mm. In alcohol the specimen measured 17 mm. long, 7 mm. high.

One specimen, collected in Elkhorn Slough, August, 1943, by Rolf Bolin was 16 mm. long.

*Eggs.* A large specimen fastened its egg band against the bottom of the aquarium dish and crawled away giving out a single straight string of eggs from the female opening at the angle of the union of the right parapodium and the body.

Genus *Tridachiella* MacFarland

*Tridachiella* MacFarland, 1924. Proc. Calif. Acad. Sci., ser. 4, vol. 13, p. 405. Genotype, *Tridachia diomedea* Bergh, 1894.

*Tridachiella diomedea* (Bergh)

*Tridachia diomedea* Bergh, 1894. Bull. Mus. Comp. Zool. Harvard, vol. 25, no. 10, pp. 194-195, pl. 1, figs. 1-7.

*Tridachiella diomedea* (Bergh), MacFarland, 1924. Proc. Calif. Acad. Sci., ser. 4, vol. 13, pp. 406-410, pl. 10, figs. 1-3; pl. 12, figs. 13-15, 18-21.

*Tridachia* (*Tridachiella*) *diomedea* (Bergh), Thiele, 1931. Handbuch Syst. Weichtierkunde, vol. 1, pt. 2, p. 415.

A preserved animal measured: body length 35.4 mm.; width, parapodia reflected, 14.3 mm.; body proper 8.3 mm. in width. Parapodia, flattened out horizontally, maximum width 20.3 mm.

The illustrations referred to below pertain to the second reference cited in the above synonymy.

*Head* well developed, rhinophores large, diameter  $1.8 \times 3.2$  mm. long.

*Foot* (pl. 10, fig. 3). Total length 33.7 mm.; the anterior portion short, 6 mm. from anterior margin to the groove.

*Mouth opening* small, a transverse furrow separates this region from the anterior foot.

*Parapodia* extend the entire length of the body, thrown into six folds, the free margin being much longer than the basal line of insertion on the body. These folds are in turn convoluted into a great number of small folds, presenting an elaborate ruffle. (Pl. 10, figs. 1, 2.)

General *color* a pale yellow to a translucent gray. Plate 10 shows the elaborate markings of black, velvety, triangular, rounded spots over the margins of the parapodia.

The *reno-pericardial* elevation (pl. 12, fig. 20) forms a prominent oval area in the anterior, mid-dorsal region, immediately behind the anterior ends of the parapodia. This prominence is 3.5 mm. long by 2.0 mm. wide. From an elevated ridge, vessels pass backward to the base of the parapodium.

Immediately in front of the right anterior ridge and slightly toward the median line, is the anal opening (*a*). Behind the center, on the right side, is located the inconspicuous renal opening (*r*).

In front of the right parapodium, as it curves inward, on the median line, is the opening of the oviduct (pl. 12, fig. 21). The obscure vaginal aperture could not be identified without dissection. At the outer base of the right rhinophore is the external opening of the penis.

The *pharyngeal bulb* is very small,  $1.4 \text{ mm.} \times 1.0 \text{ mm.}$  in height. The upper half is strongly muscular, 18-20 transverse bands; the cavity is simple. The mouth tube is surrounded by a mass of oral glands. There is no trace of mandibular parts. The cavity of the bulb is lined by a well developed cuticle. The radula is small, narrow, and compressed, making a sharp angle. Plate 12, figure 13, shows three teeth at the angle, but few are functional at the same time. There are 22 in all, about the same size, 0.195 mm. in length.

One specimen was collected by Dr. Fred Baker on San Marcos Island, Gulf of California, May 12, 1921; it is preserved in the museum of the California Academy of Sciences.

Order ACOELA  
Suborder NOTASPIDEA  
Family UMBRACULIDAE

Genus **Tylodina** RAFINESQUE

*Tylodina* RAFINESQUE, 1814. Specchio Sci., vol. 2, no. 12, p. 162. Genotype, *Tylodina punctulata* Rafinesque, *op. cit.*

**Tylodina fungina** Gabb

Plate 5, figures 6-8; plate 6, figures 12-13a; plate 11, figures 1-13;  
plate 12, figures 1-19; plate 16, figures 1-8

*Tylodina fungina* GABB, 1865. Proc. Calif. Acad. Nat. Sci., vol. 3, pp. 188-189. Type locality Santa Barbara Island, shore. DALL, 1921. U. S. Nat. Mus., Bull. 112, p. 65, pl. 15, figs. 15-17. RICKETTS, E. F., and J. CALVIN, 1939. Between Pacific Tides, p. 75, fig. 30.

This species was based upon an empty though fresh shell, taken in shore collecting by Dr. J. G. Cooper on Santa Barbara Island. Owing to the rarity of the publication the original description follows:

“T. testa sub-elliptica, elevata; apice sub-centrali; epidermide rufo-brunnea, prope apicem lutea, ultra marginem testae projecta; intus lutea prope marginem caerulescens.

“Long. 1·3, lat. 1·1, alt. ·5.

“Animal unknown, shell sub-elliptical, elevated; apex sub-central, blunt; epidermis reddish brown, yellowish on and near the apex, projecting beyond the margin of the shell; color internally straw yellow, shading towards the margin into a bluish white.

“The above measurements are approximate, making allowance for the epidermis which in the dry specimen is contracted and incurved around the margin to a width of about a tenth of an inch.

“A single specimen, fresh, though without the animal, was found by Dr. Cooper on the shore of Santa Barbara Island.

“No. 994, Mollusca, Survey Cabinet.”

The single specimen mentioned has apparently been lost, together with the other shells of the California Survey Cabinet. They seem to have been transferred to the University of California, but their final fate is unknown.

Numerous specimens of the animal and its shell have since been taken by various collectors between tide marks along the coast of southern California.

An alcoholic specimen of this species was kindly supplied to me by Mr. E. F. Ricketts, who collected it in the early spring of 1931, at or near Laguna Beach, California.



Additional specimens were made available from the Kerckhoff Marine Laboratory; these were collected at Corona del Mar by its director, George E. MacGinitie, and a fine living specimen was found by the writer near the same place while enjoying the privileges of the laboratory during April to May of 1946.

Shells of seven specimens from the same region, belonging to the Oldroyd Collection, were kindly loaned by Dr. Myra Keen, Curator of Paleontology, Stanford University.

Supplementing studies of the living material, dissections were made, and serial celloidin sections greatly facilitated the working out of finer details. While the present study cannot be regarded as complete, it has brought to light a number of important facts respecting the organization of this animal.

The following external description is based upon a living specimen which was taken on May 5, 1946, from a reef at Laguna, California. The animal was extremely sluggish in movement. When placed upon a sponge remaining in the same place, it gradually excavated a slight depression which fitted the foot. It was removed from the sponge with difficulty and placed in a dish. In a short time the tips of the rhinophores emerged from beneath the anterior margin of the shell.

*Body* elongate, broad, truncate in front, flattened behind, the visceral hump rising abruptly from the otherwise somewhat flattened body as a rather high, bluntly conical or columnar structure capped by the overlapping, nearly circular, patelliform shell, into which the animal can incompletely withdraw itself. (Pl. 5, figs. 6, 7.)

*Foot* flattened, broad, truncate in front, bluntly pointed behind, the anterior bilabiate margin deeply bilobed, the upper lamina notched, the dilated union of the two laminae forming a prominent fold at the lateral angles. This anterior end of the foot is separated from the lateral margin by a notch just behind the beginning of the bilabiate portion. Lateral foot margin thickened, broad and undulating, behind broad, depressed, undulating and somewhat spatulate; the posterior tip blunt and broadly rounded.

*Head* broad, much depressed sloping downward in front, sharply set off from the body, or visceral hump.

*Anterior tentacles.* Anterior end of head forming a convex buccal shield or oval disk, deeply grooved anteriorly to the mouth opening, its posterior border forming a low transverse ridge, the outer upper angles of the shield prolonged as short, blunt, auriform tentacles, each grooved lengthwise on its outer face.

*Rhinophores* (pl. 5, fig. 7) wide apart, well back, close to the visceral hump, 5 mm. high, bluntly cylindrical, flattened, cleft nearly their full length on the external face, the walls of the groove, thus formed, widened laterally and bearing on their inner surfaces a number of low transverse folds, highest proximally, and decreasing to faint vestiges in the distal part. (Pl. 12, fig. 12.)

*Eyes* small and inconspicuous, beneath the integument in front of the rhinophore bases.

*Mantle* completely concealed beneath the shell to which it is closely attached, its narrow margin projecting freely all around as an undulating thickened border. Its anterior portion contains large, closely set alveolar glands opening near its edge upon the dorsal side by ten to twelve ducts.

*Branchial plume* of moderate size, bipinnate, in part obscurely tripinnate. situated well back in the right posterior quadrant of the visceral hump, high up on the side of the body beneath the overhanging shell and mantle margin. Its attachment, nearly one-half of its total length, extends obliquely downward and backward, the anterior end highest. The free portion of the plume curves around behind and slightly beyond the visceral hump to the median line. It consists of a long, smooth axis bearing twelve to fourteen pinnules above and below in alternate arrangement, the ventral pinnules being much larger, longer, and more developed than the dorsal ones. Each of the dorsal pinnules is made up of a short, triangular plate bearing a number of small laminae, the largest of which may bear in turn a few, low, nearly rudimentary platelets. The ventral pinnules are much larger, plume-like in form, extending downward, outward, and backward, and decrease in size toward the tip. Each of the large pinnules bears up to ten platelets and the largest of these may show traces of further subdivisions. (Pl. 12, figs. 13, 14.)

The color of the gill in life is the same dull red as the foot, slightly darker than the general body color. (Pl. 5, fig. 7.)

*Osphradium*, a small patch of highly sensory epithelium lying close in front of, and slightly below, the anterior end of the branchial plume axis. Close behind it is the rounded and flattened osphradial ganglion from which the discoidal osphradium is supplied with nerve fibers. The ganglion is united to the suprainestinal ganglion of the visceral loop by a long connective.

*Anus* at the summit of a low cylindrical papilla, immediately above the posterior end of the attachment of the gill.

*Renal opening*, an obscure pore close in front of the anal papilla.

*Reproductive openings* close below the right anterior tentacle. (Pl. 5, fig. 7.)

*Visceral hump*, a nearly cylindrical truncated cone arising abruptly behind the head from the broader foot, its summit somewhat convex and crowned by the broadly conical shell which projects everywhere beyond it. Its antero-posterior cross section is slightly elliptical and in transverse diameter is slightly greater than the length of the head region. The shell is attached by the nearly circular columellar muscle, interrupted in the right posterior quadrant, the interval being filled by the triangular suspensor muscle of the visceral hump. The fibers of the columellar muscle pass downward in the body wall and radiate out into the tissues of the foot.

In an alcoholic specimen 21.8 mm. total length, the height of the visceral hump, from the dorsal surface of the foot to the columellar muscle, was 5.5 mm.; its antero-

posterior basal diameter was 9.2 mm., tapering to 8.0 mm. at its summit. The transverse basal diameter was 8.0 mm.

In a living specimen 16.6 mm. total length, the visceral hump had a length 10.7 mm., height 9.4 mm., width 9 mm. The height is exaggerated in preserved specimens and less prominent in life.

The visceral hump contains the stomach, liver, intestine, heart, kidney, and the reproductive organs with the exception of the large hermaphroditic duct and its branch, the spermatheca and the external parts connected with it. (Pl. 11, fig. 7.)

*Color.* Living specimen. (Pl. 5, figs. 6, 7.) The general body color in all parts is a golden yellow (aureolin). It matches so completely the color of the sponge upon which it lives that it is difficult to detect. However, the integument of the living animal reflects the light more completely making the yellow appear as a much brighter tone.

There are irregular lines and a fine spotting or network over the surface of the sides, head, and dorsum of the foot of bright lemon yellow which is clearly defined against the general body color. Transverse lines across the head, below the eyes, are of the same brilliancy and quite pronounced.

The ventral surface of the foot is slightly paler than the dorsum, deepened when contracted.

The *gill* has the yellow color of the body; the tips of the pinnules are of an intense tone.

The *shell* is canary yellow, the upper third being quite bright and clear; the embryonic tip glows and glistens. (Pl. 5, figs. 6, 7.)

The outer half or two-thirds of the dorsal surface is covered by periostracum. The general color of this is a light brown. Successive bars of dark brown form incomplete bandings on the outer third, these being interspersed with patches of red-brown (raw umber) which seems to predominate.

The margin is overlapped by an uncalcified, colorless band, 1 to 3 mm. in width. (Pl. 12, fig. 15.) The shell margin showing through is a canary yellow, while the inside is a straw yellow becoming pale about the edges. The colors and textures of the entire animal blend perfectly with the sponge upon which it lives.

*Color.* Alcoholic specimen. The foot in large specimens is frequently almost colorless as is the body, while in other large and smaller ones the general color is a deep red-brown. The gill, also, becomes this color matching the foot. Upon removing the shell there is left on the mantle a pink crescentic area.

In alcohol the shell is a very pale yellow, the membranous margin a pale rose red to a deeper shade. This marginal zone occupies a width of 1.9 mm., while the remaining portion, 5.2 mm. to the apex, is the pale yellow shell color.

In a large alcoholic specimen, 31 mm. long by 16 mm. wide, the free margin of the periostracum in front is 3.8 mm. in width. The pink coloration is lighter on the margin and it is also present in several squarish patches similar in location and form to the deep-brown ones in the living specimen.

## MEASUREMENTS

	<i>Over-all length</i>	<i>Over-all width</i>	<i>Over-all height</i>	<i>Shell length</i>	<i>Shell width</i>	<i>Shell height</i>
Ricketts specimen	21.8 mm.	17.0 mm.	13.0 mm.	16.0 mm.	14.5 mm.	6.5 mm.
MacGinitie specimens	11.9 mm.	9.0 mm.	6.5 mm.	9.0 mm.	7.0 mm.	3.0 mm.
	21.8 mm.	16.8 mm.	11.9 mm.	16.6 mm.	14.0 mm.	9.0 mm.
MacFarland living specimen	36.0 mm.	15.0 mm.	17.0 mm.	23.0 mm.	20.0 mm.	7.0 mm.

*Shell* (pl. 12, figs. 15-19) patelliform, subelliptical, the apex subcentral, directed slightly backward and to the left in two, close, translucent whorls, which are frequently lost in older specimens. Shell calcareous, moderately strong, the upper surface a clear yellow; reddish-brown periostracum over the lower half. This projects beyond the calcified shell margin as an uncalcified narrow fringe, 1 to 2 mm. wide, of thin irregular cuticular laminae overlapping in shingle-like manner. The apical one-third of the shell is usually free from this periostracum and is whitish or pale yellow. The inner surface is straw color, becoming bluish toward the margin.

The *periostracum* is made up of several layers of thin, flattened, membranous, scale-like plates, overlapping each other, the free edges worn and abraded in varying degree. It everywhere projects freely beyond the margin.

Owing to the contraction of the mantle margin in killing the animal, as well as to the lack of young material, it has not been possible to make a study of the exact relation of the periostracum to the generating epithelium of the mantle margin, but it is evidently produced by the high columnar epithelium beyond that which forms the shell itself. (Pl. 11, fig. 8.)

Dead shells may occasionally be found in tide pools, and, if old, lack the periostracal layer entirely and show more or less eroded margins.

## MEASUREMENT OF SHELLS

## Stanford, Oldroyd Collection

	<i>Length</i>	<i>Breadth</i>	<i>Height</i>
Smallest	11.8 mm.	10.3 mm.	5.6 mm.
Largest	28.0 mm.	24.0 mm.	10.7 mm.
Average	17.44 mm.	14.2 mm.	7.05 mm.

## Kerckhoff Station Collection      Five Shells

	<i>Length</i>	<i>Breadth</i>	<i>Height</i>
Smallest	9.0 mm.	7.0 mm.	3.0 mm.
Largest	16.6 mm.	14.0 mm.	9.0 mm.
Average	11.58 mm.	9.34 mm.	5.2 mm.

The heights given for the Kerckhoff shells are not as accurate as those for the Oldroyd Collection, the former having been made upon alcoholic material with the ani-

mals intact, while the latter were made upon dried shells alone. In such cases the periostracal fringe is not taken into account.

*Habitat.* Santa Barbara Island, California, on the shore (Cooper); San Pedro and San Diego (Dall); Laguna (Oldroyd); Newport Bay and La Jolla on the yellow encrusting sponge, *Verongia thiona*, which it resembles in color and texture (Ricketts and Calvin); on brown algae (Maxwell Smith, 1907, Naut., vol. 21, p. 57); on Balboa breakwater, 1949 (Mr. and Mrs. E. P. Chace); many from Newport Bay (MacGinitie); live specimen from reef at Laguna, California, in 1946 (MacFarland).

*Anterior mantle margin glands.* (Pl. 11, fig. 1.) The ducts of the anterior glands traverse radially a marginal zone of about 1 mm. in width, opening externally upon the upper surface of the mantle close to its edge. Within this zone is a thicker dense band of 1.5 to 2 mm. in width, yellowish brown in color, which is closely packed with the secretory sacculi of the glands. The distal ends of the ducts are some 0.05 mm. in diameter. They dilate as they approach the glands and scattered alveoli appear upon them.

The epithelium of the ducts is composed of large columnar cells with central, oval, dark nuclei, and clear cytoplasm.

The sacculi of the glands are large, irregular, and closely beset with alveoli, and are more or less distended with a yellow mucoid secretion. Some of the gland cells are evidently actively secreting (pl. 11, figs. 12, 13), with basal nuclei and clear alveolar cytoplasm; others are darker, much lower or even flattened, as if by the pressure of the accumulated secretion. In many instances the two phases are contiguous in the same alveolus.

The connective tissue framework of the glandular area is much reduced, so the adjacent gland sacculus and its alveoli are in close contact, the layers of muscle beneath the dermal epithelium evidently controlling the expulsion of the secretion from time to time.

No trace was found of secretion cells of the Blochmann type, *i.e.*, a very large flask-shaped secreting cell provided with a multi-cellular duct and with an external capsule of muscle fibers and connective tissues.

Vayssière's (1885) brief reference to anterior mantle glands in *Tylodina* and more detailed account of them in *Umbrella* (*Umbraculum*) indicate their presence. According to Mazzarelli, multicellular acinous mantle glands are present in *Tylodinella*, but each is said to open by a separate duct on the ventral surface of the mantle, and no indication is made as to their limitation to the anterior margin of the mantle.

Marginal glands are limited to the anterior third of the circumference of the mantle, scattered unicellular gland cells in the epithelial layer being found.

*Pedal glands.* The upper and lower laminae of the anterior end of the foot are thickly beset with basophile, mucous, unicellular gland cells. Each of these consists of a flask-shaped body lying well below the outer epithelium with which it is connected with



the surface by a slender process. These are especially abundant and closely packed in the upper lamina, less so in the lower.

Throughout the whole length of the sole of the foot, similar gland cells are scattered, though much less abundantly. No sign of a special pedal gland is found at the posterior end of the foot.

*Pharyngeal bulb.* This is relatively large, flattened slightly, and bluntly conical, nearly filling the entire body in front of the visceral hump. In a specimen of 21.8 mm. total length, it measured 7.4 mm. in length with maximum height and width of 4 mm. A small transversely flattened protuberance at the posterior ventral border of the bulb is formed by the proximal end of the radula sac. (Pl. 11, fig. 1.)

No trace of paired mandibles, such as characterize Anaspidea, are to be found in *Tylodina*. The mouth tube is lined with a columnar epithelium bearing a strong cuticula continuous outward over the external lip.

The outer portion, covering the floor and sides of the tube, presents a series of irregular tessellations in the cuticle formed by the basal thickenings of its substance which appear as reticulations in transparent preparations. (Pl. 11, fig. 2 at *a.*) These ridge-like thickenings extend down between and over the summits of closely set epithelial papillae. (Pl. 11, fig. 3.)

The surface of the cuticle above the papilla is in places slightly arched, giving the free surface a pebbled appearance, in other areas it is nearly smooth. Such superficial roughness might add to the prehensile efficiency of the mouth tube in aiding the action of the radula, but the tissues of the sponge do not present much resistance to the rasping attack of the *Tylodina*.

On the dorsal side of the tube, these papillae are replaced by longitudinal ridges of epithelium and the cuticle covering these ridges and dipping into the furrows between gives them the appearance of longitudinal lines. (Pl. 11, figs. 2, 4.)

The epithelium of the roof of the tube, however, becomes smooth, and the thick cuticle in consequence presents no basal ridges as in the roof of the mouth opening. At the level of the anterior furrow of the radula all such markings disappear entirely.

Vayssi re (1883, p. 35; 1885, p. 156, pl. 5, fig. 136) described in *Tylodina citrina* a complete ring of chitinous papillae at the entrance of the mouth opening forming a mandibular ring as it were. His description and figures are evidently based on surface preparations, while sections show the true relations.

*Radula* (pl. 12, figs. 1-10) light yellow, broad, squarish, its flattened surface but slightly convex, the anterior end dipping downward into a shallow transverse groove, the posterior end passing downward into a similarly placed, but much deeper groove, the radula sac, the proximal end of which projects as a slight elevation upon the lower posterior face of the bulb. The lateral margins of the radula curve downward very slightly. No median longitudinal groove such as is characteristic of the Pleurobranchidae is here found, and the median series of teeth can only be distinguished by close scrutiny under a high magnification. The quite small lateral teeth are arranged in nearly transverse rows.

Length of radula (of 21.8 mm. specimen) 5.0 mm., its width 2.8 mm. when flattened out on slide. The rows of minute teeth number 112 to 126 and 100 to 120 teeth are present in each half row, the radula formula being 112-126 (100-120-1-100-120) (100-116-1-100-116). This does not take into account all of the rudimentary outer lateral teeth which diminish outwardly to scarcely more than slight cuticular thickenings. The teeth are borne upon a very thick cuticular basement layer which is continued forward in front of the anterior radular groove as the cuticle of the oral tube. Plate 12, figure 10, represents a sagittal celloidin section through three teeth in successive rows, showing their relations to the basement layer and epithelium. In this thin section the lateral denticle is not shown.

The rachis is very narrow and inconspicuous, the much compressed median tooth (pl. 12, figs. 1, 2) bearing a low, pointed cusp, its tip but slightly raised above the base. The latter is broadest toward its rounded hinder end, reaching a diameter of 0.007 mm. Its pointed front end is wedged in between the converging ends of the adjacent laterals, its total length being 0.022 mm. The lateral teeth are fairly uniform in size until the outermost ones are reached. Each consists of an elongate compressed base bearing upon its upper surface a strong, pointed cusp directed upward and backward. Close to its origin from the base, it bears on its inner face a single, strong denticle in shape similar to the main cusp. (Pl. 12, figs. 4, 5.) The sloping, rounded anterior end of the base of each lateral tooth is flattened and curved toward the median line of the radula, the single lateral denticle being inclosed in the bay thus formed upon the inner face of the tooth. The opposite or outer face of the anterior half of the base of each lateral is slightly expanded into a wing-like rounded process which somewhat overlaps the adjacent base of the next outer tooth. (Pl. 12, fig. 1.) The lateral teeth fit closely together, but I am unable to make out any articulation of adjacent teeth, such as is described by Pruvot-Fol and Fischer-Piette (1934) for *T. cervina* of the Mediterranean, though certain appearances of the inner lateral denticle might lead to its interpretation as an articulatory process.

Toward the margin of the radula the lateral teeth decrease somewhat in size, the denticle disappears, the cusp becomes rudimentary, and the tooth is reduced to narrow, flattened, cuticular platelets with a slightly thickened posterior end. These finally appear only as vaguely defined rectangular thickenings of the basement cuticle and fade away. (Pl. 12, fig. 3.)

In ventral view (pl. 12, fig. 2) the base of the lateral teeth thins away to a serrate ridge behind, while the remainder is thicker and curves toward the middle of the radula. The base of the median tooth is long and narrow, pointed in front and thinning away behind to a narrow, pointed, or jagged edge. The cusp arises about midway of the length of the base and extends forward to the anterior end as a strong elevation as seen in side view. (Pl. 12, figs. 8, 9.) A dislodged lateral, from the oldest part of the radula, shows two denticles. (Pl. 12, fig. 6.)

A malformed lateral tooth, repeated serially throughout nearly the whole length of the radula, shows a very large and strong denticle on its inner face, reaching nearly



the size of the cusp of the tooth in the same rows. There is no question as to this being a denticle and not an articulation as claimed by Mme. Pruvot-Fol and Fischer-Piette. There is no sign of an articular cavity in the next adjacent tooth for it to fit into, and it clearly overlaps the margin of its fellow inwards and is in turn overlapped by the one exterior to it.

In one radula, malformed teeth were noted in a single series extending through its posterior half, involving the same tooth in successive rows. The malformations consisted of the presence of several very large lateral denticles on the outer face of the tooth, in size closely approaching the main cusp.

The radula of the Mediterranean species, *Tylodina cervina*, as described by Vayssi re (1885), differs from the present species in the general form of the teeth and in the presence of two or three denticles upon each side of the cusp of the median tooth and with denticles on both the outer and inner faces of the cusp of the laterals.

*Salivary glands.* (Pl. 11, figs. 10, 11.) A single pair, lobulate, flattened and compact, are found upon the posterior face of the bulb close to the nerve ring. A single median lobe exists extending downward beyond the main paired ones. Their ducts pass forward through the circle of the central nervous system ganglia and open independently into the bulb cavity, above the radula, at either side of the exit of the oesophagus. But one pair of salivary glands is present, not two as in Pleurobranchidae and *Umbrella*.

*Blood gland.* A blood gland, such as indicated by Pelseener (1894, p. 29) as lying beneath the pericardium and above the adnexed genital complex, is not recognizable here either in dissections or in serial sections.

The *oesophagus* (pl. 11, fig. 1) emerges from the upper posterior face of the pharyngeal bulb as a narrow tube of uniform diameter and longitudinally plicated lining. It passes at once downward through the nerve collar, thence curving to the right and backward, dilates abruptly into the muscular first, or triturating stomach (*a*).

This gizzard is concealed in the compact liver-ovotestis mass, save upon its lower right surface where it is exposed. In form it is somewhat ovoid or pyriform, is nearly erect, and above contracts into the (upper) pyloric or glandular stomach (*b*). The latter is essentially formed by the union of a number of wide biliary ducts which ramify in the liver substance (*c*). From the anterior portion of this cavity the intestine is prolonged to the right and backward and opens externally upon a prominent anal papilla on the right posterior side of the animal above the hindmost portion of the gill attachment. (Pl. 11, fig. 1, *e*.)

The muscular wall of the gizzard consists of two layers, an outer circular one of uniform thickness and an inner one of longitudinal fibers chiefly arranged in some 15-20 bands extending from the anterior to the posterior openings. In the main these are parallel, but there is occasional fusing of adjacent bands.

The inner lining of the organ is elevated into ridges corresponding to the muscular bands. The lining epithelium bears a strong cuticular layer, between the ridges homogeneous (pl. 11, fig. 5), but upon the ridges modified into closely set *rod-like* cuticular

filaments of varying length, the longest reaching 0.15 or 0.20 mm. in length with a fairly uniform diameter of 0.007 mm. No structures of chitin such as are described by Vayssi re are found, and there are no surface imprints of such structures.

The prominent folds of the oesophagus lining continue into these gastric ridges with corresponding changes in their epithelial cells (*a*), while at the pyloric end (*b*) the ridges become lower and merge with low folds of the pyloric epithelium, the muscular layers being greatly reduced. (Pl. 11, fig. 6.)

As stated before, the pyloric or glandular stomach is formed by the confluence of several wide ducts (*c*) which ramify and terminate as the acini of the liver substance. The branchings of the liver interdigitate so closely with those of the ovotestis that it is impossible to separate them by dissection, the two organs forming a compact mass with no external indications of their respective limits.

Vayssi re (1883, pp. 38-39, pl. 2, fig. 24; pl. 3, fig. 34) has described for *Tylo-dina citrina* the existence of low irregular chitinous papillae arranged in rows upon the inner surface of the stomach, briefly confirmed by Pelseneer (1894, p. 29, pl. 10, fig. 82). The structures indicated by these authors are clearly different from the rodlets here described, which are much more slender, somewhat flexible, and evidently not so well adapted as a grinding mechanism such as is found in related forms. Mazzarelli (1897, p. 602, pl. 23, fig. 4) briefly described and figured pointed chitinous teeth as occurring in great numbers in *Tylo-dinella trinchessii*.

The *kidney* is a roomy, thin-walled sac lying dorsally above the pharyngeal bulb, the adnexed reproductive gland complex, and the anterior liver-ovotestis mass, and extending backward on the right side. From its dorsal anterior wall a number of incomplete partitions extend inward increasing the surface of the kidney lining while not dividing it up into the spongy type of structure found in some forms.

The reno-pericardial communication is formed by a slender duct opening into the hinder portion of the pericardium near the entrance of the auricle (branchial artery) from the gill, by a ciliated funnel-like expansion.

The *renal pore*, a minute opening close to and above the anterior end of the gill, is found very slightly behind the origin of the first ventral plumule, close in front of the anal papilla. (Pl. 11, fig. 1 at *e*.)

The *heart* as seen in dissection, is placed vertically immediately to the right of the median line. The muscular ventricle is directed downward, its upper end communicating with the wide thinned auricle above.

*Reproductive system.* (Pl. 16, fig. 1, semi-diagrammatic.) Upon the right lower face of the visceral mass is a deep concavity into which fits the posterior face of the adnexed genital complex. This mass extends transversely across the mid-body line behind the pharyngeal bulb. Bounding this cavity above is the ovotestis. The lobules of the ovotestis are finely divided and closely interlace with those of the liver so that the two organs cannot be separated by dissection. As seen in serial sections, many of the acini contain both ova and sperm, in others but one of these, so that the statements of Pel-

seneer (1893) and of Mazzarelli (1897, p. 603) as to separate acini for each kind of reproductive element in Mediterranean species of *Tylodina* and *Tylodinella* do not hold for the present species. Furthermore my interpretation of the reproductive system is decidedly at variance with that of these authors as will be seen.

From the branching terminal acini, slender ducts arise and unite in the common hermaphroditic duct. As this leaves the ovotestis (pl. 16, fig. 1) it swells abruptly into the hermaphroditic ampulla, which passes outward, downward, and forward along the lower border of the adnexed genital complex, thence outward and upward on its anterior face, describing a nearly circular loop. Narrowing into a slender duct, it enters a thin-walled ciliated chamber into which open widely the passages of the compact lobules of the albumen and mucous glands of the complex.

Close to its entrance emerges the thin-walled common genital duct which penetrates the inner layers of the integument and passes directly forward, imbedded in the musculature of the right body wall, to the external genital opening close below the right anterior tentacle. (Pl. 5, fig. 7; pl. 16, fig. 7.) It is traversed by a strong longitudinal fold or ridge, which incompletely divides it into two channels (pl. 16, fig. 7, *a*, *b*) and is evidently comparable to the "large hermaphroditic duct" of *Aplysia*. The narrower of the two grooves thus formed is lined by a low, columnar epithelium bearing very long cilia, in length equalling the height of the cells themselves. (Pl. 16, fig. 2, *a*.) In the ciliated chamber of the adnexed genital complex this groove is continuous with a similar ciliated furrow leading directly to the entrance of the hermaphroditic duct. The adjacent groove on the opposite side of the median thickened ridge (pl. 16, fig. 2, *a*) is lined by a cuboidal epithelium, in part ciliated. Its surface is increased by several quite low longitudinal folds parallel to the median ridge and near to its base.

Within the dilated ridge itself, and adjacent to its base, are a number of closely packed, short, alveolo-tubular glands opening into the lumen of the duct and containing fine secretion granules. Similar glands are continued into the fertilization chamber for a short distance and extend along the full length of the genital duct to its external opening.

Close to the external opening, the common genital duct receives on its dorsal side a stout muscular duct nearly equalling it in diameter approximately 0.6 mm. long. This dilates rapidly and passes backward in the integumentary wall in close contact with, and parallel to the common genital duct. (Pl. 16, fig. 8, *a*, *b*.)

Reaching the adnexed genital complex, it terminates upon its upper anterior face as a blind dilated sac extending transversely behind the pharyngeal bulb. (Pl. 16, fig. 1.) Throughout its length it has a thick muscular wall of mainly circular fibers and an adventitious layer closely united to that of the common genital duct and the integument. (Pl. 16, figs. 3, 4.) Its lining is thrown into a variable number of longitudinal ridges, its epithelium is made up of high columnar cells in whose distal ends a myriad of sperm heads are either buried or in intimate contact. (Pl. 16, fig. 5.)

In the proximal dilated end of the sac this orientation of the sperm is lost and a considerable amount of cellular debris is also accumulated. The sperm head is in the

form of a close, deeply staining spiral of some six turns, the tail projecting freely into the lumen of the tube. (Pl. 16, fig. 6.)

This organ manifestly is the spermatheca or receptaculum seminis, and the contained spermatozoa have been received from another individual in pairing. The accompanying duct is the common hermaphroditic duct of such forms as *Aplysia*, the two incompletely separated channels formed by its longitudinal fold, one representing the spermatid duct to the exterior, the other representing the oviduct.

Contrary to the findings of Mazzarelli (1898) for *Tylodinella trinchessii*, the hermaphroditic duct does not divide into two rami as it leaves the ovotestis, one passing to the adnexed genital complex as the oviduct, the other passing directly to a separate, external, male opening, dilating, as it does so, as the vas deferens ("deferente").

If my interpretation is correct, we have here for *Tylodina fungina* the monaulic type of genital duct such as is found in Cephalaspidea generally, i.e., *Gastropteron*, Bullidae, Aplysiidae, *Umbraculum*, and most Pteropoda, and not the diallic type, as claimed by Mazzarelli for *Tylodinella trinchessii*.

Furthermore, a very short external spermatid furrow leads from the common external genital opening to the penis, which is clearly noninvaginable, but is represented by a short, external, integumentary process immediately below the base of the right anterior tentacle. This is somewhat triangular and shield-like in form, the thin outer margin is finely scalloped. (Pl. 16, fig. 7.) This organ bears a ciliated groove upon its upper concave surface which is a continuation of the similar groove to its base from the common genital opening. (Pl. 16, fig. 8.) Thus we have for *Tylodina fungina* a common ovo-spermatid duct with a single external opening and a very short external spermatid groove in the integument beyond it leading to a noninvaginable external verge. This latter condition appears to occur only in *Actaeon* (Pelseneer, 1894, p. 9) and in *Umbraculum*. In *Actaeon*, however, the spermatid duct runs beneath the integument, and arises far back by the division of the hermaphroditic duct into sperm duct and oviduct, with separate external openings - the diallic type. This is usually considered to be the most primitive condition among the Cephalaspidea, but evidently *Tylodina*, as here described, is more primitive.

*Central nervous system.* The excellent description and figures of Vayssière (1885, pp. 158-160, pl. 5, fig. 135) of *Tylodina citrina* apply in the main to *Tylodina fungina*. The nervous system (pl. 12, fig. 11) exhibits the marked concentration of the main ganglia around the oesophagus, the pleural ganglia are fused with the parietal ones and the pleuro-visceral connective is so shortened that the pleural, the parietal ganglia (suprasubintestinal ganglia), and the single visceral one appear almost as if fused, the connectives being made out in serial sections.

The rounded cerebral ganglia are united above the oesophagus by a short and broad commissure, and below it by a slender, longer, infra-oesophageal one.

The considerably larger pedal ganglia are united to the cerebral pair by very short cerebro-pedal connectives, in fact the ganglia are almost fused, the connectives be-

ing best made out in serial sections. The inner faces of the pedal ganglia are in close contact, being united by one extremely short and broad commissure and, behind it, by a slightly longer and slender parapedal one.

In *Tylodina citrina*, Vayssière described and figured much longer pedal and parapedal commissures than here found. The connectives of the visceral loop, composed of distinct right and left pleuro-parietal ganglia and a single visceral ganglion, are extremely short, about as figured by Vayssière. The ganglia are placed close upon the posterior face of the oesophageal nerve ring, concealing the upper posterior surfaces of the pedal ganglia and their connection with the cerebral pair.

The small elongate-ellipsoidal buccal ganglia lie close above the cerebral ganglia in front of the oesophagus, between it and the hinder face of the pharyngeal bulb, and are united by a very short buccal commissure. The nerves from the ganglia are distributed as indicated by Vayssière.

The oesophagus, emerging from the posterior vertically truncate end of the pharyngeal bulb, passes almost perpendicularly downward to the ventral surface of the viscera before curving backward to the stomach. In consequence of this position, the nerve ring of central ganglia is also vertical in position, the cerebral ganglia, indeed, being inclined somewhat backward and the pedal pair being virtually in front of the cerebral ones, and below them, instead of behind them, as is uniformly represented in figures of the gastropod nervous system. (Pl. 11, fig. 1.)

	<i>Tylodina citrina</i>	<i>Tylodinella</i>	<i>Tylodina fungina</i>
Cerebral commissure	Relatively short	Very long	Moderately short
Pedal commissure	Long	Short	Very short
Cerebro-pedal commissure	Short	Moderately long	Very short
Connectives of visceral loop	Short	Moderately short	Very short

*Nerves* of the cerebral ganglia are distributed substantially as in *Tylodina citrina*. No distinct optic ganglia nor rhinophoral ganglia are to be found, the distal nerve cells of the rhinophore plates being small and diffusely distributed below the sensory epithelium.

The osphradium and its ganglion have been figured by Pelseneer (1894, pl. 10, fig. 82) at a magnification of 45 times, and dismissed on page 28 of the text with the short statement that "*Tylodina* est le seul Pleurobranchien qui possède encore un ganglion osphradial et un osphradium sur le nerf branchial au bord droit du manteau en avant de la branchie." Mazzarelli (1897, p. 601, pl. 24, fig. 20) confirmed the statement of Pelseneer but with no details.

The osphradial ganglion in *T. fungina* is imbedded in the integument close in front of the anterior end of the gill, and directly beneath the inconspicuous oval osphradium to which it sends nerve fibers.



## Family PLEUROBRANCHIDAE

## Subfamily PLEUROBRANCHINAE

Genus *Berthella* BLAINVILLE

*Berthella* BLAINVILLE, 1825. Man. Malacol., pp. 469-470. Genotype, *Berthella porosa* Blainville.

*Berthella sideralis* (Lovén)

Plate 13, figures 1-13

*Pleurobranchus sideralis* LOVÉN, 1846 [1847]. Index Moll. Litora Scand. Occidentalis habitantium. Öfvers. Kgl. Vet. - Akad. Förhandl., III (5), 1846, p. 140.

*Pleurobranchus plumula* (Montagu), SARS, G. O., 1878. Mollusca Regionis Articae Norvegiae, p. 457, pl. 13, fig. 1a-m.

*Pleurobranchus sideralis* Lovén, BERGH, 1898. Mal. Unders., vol. 4, no. 1. Die Pleurobranchiden, 3, pp. 126-129, pl. 9, figs. 51, 52; pl. 10, figs. 1-11; pl. 12, fig. 22.

*Berthella sideralis* (Lovén), ODHNER, 1926. Die Opisthobranchien. Zool. Results, Swedish Antarctic Exp., 1901-1903, vol. 2, no. 1, p. 22. ODHNER, 1939. Opisthobr. Moll. from the western and northern coasts of Norway. Kgl. Norske Vidensk. Selsk. Skr., no. 1, pp. 15-24, text figs. 4, 6, 8, 10, 12.

*Berthella sideralis* was described by Lovén in 1847 as *Pleurobranchus sideralis* from specimens taken on the Norwegian coast. Not until 1878 was any further record or study made of it when G. O. Sars figured the mouth armature of a tectibranch which he identified as *Pleurobranchus plumula* (Montagu), differing markedly, however, from other accounts as pointed out by later authors. Not until 1898 was the difficulty cleared up by Bergh, who showed that Sars had before him *Pleurobranchus sideralis* Lovén and not *Pleurobranchus plumula* (Montagu) at all. Bergh gave a brief anatomical account of the species with important figures.

Since "*Bouvieria sideralis*" has been questionably recorded by Bergh (1898, p. 128) as having been taken near Unalaska in 25 fathoms by Dall in 1881, his description of *Berthella* specimens from Trondhjem Fjord, Norway, together with some of his figures are here reproduced. (Pl. 13, figs. 1-9.) They may facilitate the identification of other Alaska specimens, since the characters of mandibles and radula are unmistakable. The Dall specimen upon which the record is based was unfortunately quite mutilated, the pharyngeal bulb being entirely absent, without which accurate identification is nearly impossible. No other record of its occurrence in Alaskan or North Pacific waters has been found.

*Body color* in life according to Lovén is sub-pellucid white, in alcohol yellowish white, slightly darker above in the shell region. Length of eleven specimens ranged from 11 to 17 mm., the largest measuring 12 mm. in width, 8 mm. in height; the head width with tentacles 8 mm., the height of the rhinophores 3.5 mm., the gill length 3.5 mm.,

its maximum width 2.75 mm., the width of the mantle margin 3 mm., the width of the foot margin 3.5 mm., the length of the tail 5 mm.

*Body form* as in *Pleurobranchus aurantiacus*, i.e., elongate-elliptical, convex; the mantle relatively small; buccal veil trapezoidal; foot large, extending beyond the mantle all around.

*Genital papilla* with its two openings as usual, above it the fine prebranchial opening. Gill plume with twenty to twenty-five plumules, the hinder one-fourth free from union with the body wall, the anal opening at the end of the gill attachment. Foot bilabiate in front, the upper lip strongly notched in the median line.

*Shell* covering the viscera entirely, 14.5 mm. long, 9.5 mm. wide, and 5 mm. high, dull milk-white in widest portion, more yellowish in front, the dull color due to extremely abundant and varying nodules and markings between and upon the growth lines. Spire rather prominent, the whole shell solid, calcified to margin but fragile. (Pl. 13, figs. 1 *a-b*.)

Skin of dorsum reinforced by abundant, mainly many-rayed spicules of irregular form, some measuring 0.6 mm. in length. (Pl. 13, fig. 3.)

*Pharyngeal bulb* 4.5 mm. long, 3.5 mm. wide behind, 2.5 mm. high in front. The amber-colored mandibles 4.0 mm. long, the mandibular plates up to 0.11 mm. long, 0.06 mm. wide, and 0.055 mm. high, the median cusp (pl. 13, fig. 4) with a row of from 3 to 15 nearly equal, pointed denticles. Radula light yellow, teeth in 92-95 rows of about 200 teeth in each (half) row, the rachis naked. Radula formula 92-95 (200.0. 200) for two specimens. Teeth colorless, save in basal part which is yellow, the innermost but 0.035 mm. high, gradually increasing outwardly to 0.14 mm., decreasing again gradually to 0.06 mm. in the outermost. The innermost (pl. 13, fig. 6) teeth are in close contact, the basal plate forked behind, the tip low and slightly hooked; the most of the lateral teeth with rather large base and erect shaft, bent into a moderate hook at the distal end, without denticles; the outermost plates very slender, awl-like. (Pl. 13, fig. 7.)

#### Genus *Berthellina* GARDINER

*Berthellina* GARDINER 1936. Journ. Conchol., vol. 20, no. 7, p. 198. Genotype, *Berthellina engeli* Gardiner.

#### *Berthellina engeli* Gardiner

Plate 13, figures 14-24; plate 16, figure 9

*Pleurobranchus plumula* BERGH. 1893. Res. Comp. Sci., Albert I. Monaco, Fasc. 4, pp. 19-26, pl. 2, figs. 43-50; pl. 3, figs. 51-67. Not *Pl. plumula* (Montagu). BERGH. 1894. Bull. Mus. Comp. Zool. Harvard, vol. 25, no. 10, pp. 197-199, pl. 9, figs. 12-14; pl. 10, figs. 1-8. BERGH. 1898. Mal. Unters., vol. 4, nos. 1, 3, pp. 122-126, pl. 9, figs. 48-50.

*Berthella plumula* VAYSSIÈRE. 1896. Ann. Sci. Nat. Zool., ser. 8, pp. 271-277, pl. 18, figs. 17-30. BERGH. 1905. Mal. Unters., vol. 6, no. 2, pp. 58-59, pl. 6, figs. 7-12.



*Berthellina engeli* GARDINER. 1936. Journ. Conch., vol. 20, no. 7, pp. 195-198. ODHNER. 1939. Kgl. Norske Vidensk. Selsk. Skr., no. 1, pp. 15-21.

The first record of the occurrence of *Berthellina engeli* (as "*Berthella plumula* (Montagu)") in the eastern Pacific waters of North America is by Bergh (1894) in his report upon the dredging operations of the *Albatross* in the Gulf of California and adjacent waters, a single specimen having been taken in Lat. 24° 11' N., Long. 109° 55' W., i.e., off the Bay of La Paz in 10 fathoms depth. Bergh identified the animal with *Berthella plumula*.

In Steinbeck and Ricketts (Sea of Cortez. 1941. Appendix, Annotated Phyletic Catalogue, page 542) the species is listed on my authority, I having been guided in a preliminary identification by the descriptions of Bergh and Vayssi re. Further study, however, has convinced me that the species in question is *Berthellina engeli* Gardiner, 1936, and is not to be confused with the true *Berthella plumula* (Montagu) 1803.

I have had for examination the following material:

1. Seven specimens collected by H. N. Lowe at Punta Pe asco, Sonora, Mexico, between tide marks, 1934. The shells had been removed from these, and the preservation was not of the best.

2. Collections made by the Steinbeck-Ricketts Expedition to the Gulf of California in 1940, between tide marks at the following stations:

- a. Point Lobos, Esp ritu Santo Island, three specimens. "Fairly common."
- b. El Mogote, Bay of La Paz, one specimen.
- c. Puerto Escondido, three specimens.
- d. Los Angeles Bay, one specimen.
- e. Puerto Refugio, Angel de la Guardia Island, three specimens.
- f. Puerto San Carlos (near Guaymas), Sonora, two specimens.

It has been claimed that this species has been taken in the San Diego region, but I have thus far found no authenticated report to that effect. Pease (1861) described as new *Pleurobranchus delicatus* from the Society Islands (Huahine), which is considered by Baba (1937) to be identical with the Japanese *Berthella gotoi* Hirase (1936) and now held to be a variety of *B. plumula* (= *Berthellina engeli*).

It is recorded from Misaki and Amakusa, Japan. So far as known, these agree with *B. engeli* in all respects save in the shell, which is narrower behind instead of equally rounded in front and behind.

*Berthellina borneensis* Bergh, (1905) has a similarly shaped shell and may likewise be a variety. The characteristic denticulate blade-like radula teeth fix these as belonging to the genus *Berthellina*.

**Size.** The alcoholic specimens studied range in length from 12.5 mm. to 35 mm., 9.7 mm. to 25 mm. in width, and 7 mm. to 13 mm. in height. Measurements of preserved material, however, can give only an approximate idea of the actual size of the living animals, owing to the varying degree of contraction, inrolling, and the like. Only rarely is the body form accurately preserved, while the color in life is always lost. For

purposes of comparison, however, such measurements have decided value if these limitations be kept in mind.

*Dorsum* elliptical in outline, equally rounded in front and behind, the anterior border slightly emarginate, the dorsal surface somewhat convex, smooth, and soft, or, rarely, with traces of low, closely set tubercles. Central area usually thin, the marginal zone thicker and projecting well beyond the edge of the foot.

*Shell* small, thin and delicate, in some specimens being scarcely more than membranous, in others exhibiting a slight degree of fragile calcification, the narrow marginal zone all around membranous. Elliptical in outline, slightly arched, consisting of an obliquely placed small spire of two and one-half close turns, the anterior margin of the outermost whorl becoming greatly expanded and enlarged to form the bulk of the shell. Lines of growth clearly defined, the longitudinal lines much less so, but traceable outward to the shell margin. In size the shells range from 4.3 mm. long by 2.4 mm. wide, 3.5 mm. long by 2.5 mm. wide, 4.0 mm. long by 2.5 mm. wide, to 3.2 mm. long by 1.9 mm. wide in specimens of 26 mm., 20.5 mm., 19.3 mm., and 12.5 mm. in body length respectively. Thus the length of the shell varies roughly from one-fourth to one-sixth the body length. Since body length varies in accordance with the degree of contraction caused by the fixation, such ratios are of necessity approximate only. In each case the shell is borne far back, behind the middle of the body length. (Pl. 13, fig. 14.)

*Head*, velum broad, somewhat semicircular in outline, nearly as wide as the foot, the outer angles bluntly pointed, the lateral margins with a shallow groove along their full length.

*Rhinophores* short, stout, cylindrical or slightly flattened, made up of a folded plate forming an external groove, the lower (anterior) margin of which is thin and expanded beyond the upper. Bases of the closely set rhinophores united in the median line.

*Foot* completely covered by the mantle except behind, where the bluntly pointed tip may project slightly. Anterior angles rounded, the anterior margin bilabiate. No indications present of a differentiated pedal gland at the posterior end of the foot.

*Gill plume* small, bipinnate, completely concealed between the mantle and foot margins on the right side, its posterior end free from the body wall for less than one-half of its total length. Rachis smooth, pinnules seventeen to twenty-two, without any trace of tubercular enlargements at their origins from the rachis.

*Anus* situated immediately above the posterior end of the attachment of the gill plume to the body wall.

*Reproductive openings* on right side close in front of anterior end of gill, surrounded by a low, collar-like fold of the integument, fairly uniform in height save at the upper posterior portion where it is modified into a higher rounded lobe, united with the collar by much lower continuations. In most of the specimens examined the terminal portions of the reproductive ducts were more or less evaginated and distorted. The an-

terior opening is that of the bluntly conical penis or verge, close behind it is the crescentic opening of the vagina, and behind the latter the large aperture of the oviduct and nidamental gland complex. In complete retraction the last two may seem to open into a common cloaca by which they communicate with the exterior.

*Prebranchial sac.* Opening very small, close behind and slightly above the reproductive openings.

*Renal opening* in front of the gill above the reproductive openings.

*Mandibles* (pl. 13, fig. 15) elongate, rectangular, slightly concave, the hinder, younger end rounded, the slightly curved dorsal and ventral margins nearly parallel, the anterior end exposed beyond the sheath, reflected outward at the anterior end of the bulb cavity and worn through use. Pale amber in color becoming darker at the anterior end.

In a specimen of 20.5 mm. total length, the mandibles were 5.9 mm. long by 2.4 mm. wide, the whole pharyngeal bulb measuring 9.1 mm. in length, 2.7 mm. wide, and 2.7 mm. in height.

Mandibular elements (pl. 13, figs. 16-20) closely fitted together in a tessellated pavement, the anteriorly directed, pointed, smooth cusp forming a continuation of the inclined dorsal surface of the irregular body. Laterally a short blunt process meets a similar one of the neighboring element in the same row, behind the hinder end of the element immediately in front. These processes are not exactly opposite, those on one side being slightly in advance of those on the opposite side, thus determining the slight obliquity of the rows. (Pl. 13, figs. 16, 19.) Toward the dorsal and ventral margins of the mandible, the elements become somewhat more irregular in form and depart from the typical shape found in the central areas.

The body of each element is short and prismatic in general form, thick in the anterior older part of the mandible, but becoming thinner toward the posterior younger end. The cusp, raised above the general level of the mandible, is entirely smooth without any denticulation. (Pl. 13, figs. 17, 18.) The length of the average elements in the anterior portion of the mandible is .180 mm. to .192 mm., their transverse width between the ends of the lateral plates is .048 mm. The size of the plates increases but slightly toward the younger posterior portion; in front the cusps are worn or broken through use. The elements are basally united by a common cuticular layer which thins away behind and disappears before the posterior sulcus is reached in which the elements are formed.

*Radula* small, with 60-100 rows of flattened blade-like lateral teeth. Rachis very narrow and naked, laterals about 170 in each half row. Innermost teeth of each half-row shorter and broader than the remainder, a typical innermost tooth averaging 0.09 mm. in length while the longest laterals reach 0.21 mm. to 0.23 mm. (Pl. 13, figs. 21-24.)

Each lateral tooth is nearly erect, flattened, slightly curved; its tip curves backward in a blunt point and below it are borne from eight to ten small denticles upon its distal posterior margin. The first of these denticles is broad and bluntly pointed (pl. 13, figs. 23, 24) and is nearly as large as the tip of the tooth, the interval between it and the end of the tooth being relatively large. The remaining denticles are much smaller and decrease progressively in size downward, disappearing before the mid-length of the tooth is reached. Occasionally but one denticle is found below the tip in the outermost teeth, but usually a varying number of rudimentary smaller ones may be made out. In some instances the uppermost denticle approximates the size of the tip of the tooth, giving it a bifid appearance, but usually the first denticle is distinctly smaller than the tip, but larger than the remaining ones.

*Reproductive system.* (Pl. 16, fig. 9.) The ovotestis covers the upper anterior portion of the right end of the liver. From it arise numerous ducts which unite in the main hermaphroditic duct, dilating at once into the long ampulla, which passes forward beneath the intestine to loop around the inner upper border of the anterior genital complex.

The ampulla is some 16 mm. in length and 0.8 mm. to 1.2 mm. in diameter, varying in preserved material owing to different degrees of distension and the pressure of adjacent organs along its course. At the ventral surface of the anterior complex it loops around the spermatheca, the spermatocyst, and the prostate gland, and divides into the very short spermatic duct (vas deferens) and the longer oviduct.

The vas deferens at once enters the ellipsoidal prostate gland, while the longer oviduct passes outward into the nidamental-albumen gland complex, opening into its duct near its distal end.

The reniform prostate gland is about 3.0 mm. in length by 1.4 mm. in width, and is of rather loose texture. The vas deferens, emerging from the prostate gland, passes outward in an undulating course to the base of the penis. Here it is joined by the short duct of a long convoluted tube, dilated for the greater portion of its length of some 11 mm., to a diameter of about 0.4 mm., and ending blindly. It is lined by a layer of cuboidal glandular cells, and is distended by coagulated secretion.

This probably corresponds to the accessory prostate described by Vayssi re (1898, p. 235, pl. 27, fig. 180) in *Berthella* (= *Berthellina*) *brocki*, which it closely resembles. Bergh (1893) made no mention of its occurrence in "*Pleurobranchus plumula*" from the Azores. Vayssi re described an accessory prostate in *Bouvieria ocellata* and *Bouvieria perforata*.

It is constant in the Gulf of California specimens of *Berthellina engeli* which I have dissected, and I have also found a similar structure in *Pleurobranchus strongi*, new species, and *Pleurobranchus californicus* Dall, described later in the present paper.

Beyond the entrance of the duct of this accessory prostate gland, the vas deferens describes a number of close loops at the base of the penis, and continues thence as a slender tube to the external opening at the tip of the conical curved glans.

The external opening of the vagina is close behind the penis at the inner side of

the base of a slightly concave semicircular lobe (pl. 16, fig. 9) of the collar-like fold surrounding the external openings of the reproductive organs.

The vagina, 2.5 mm. long with a maximum width of 1 mm., narrows toward its proximal end and receives the short duct of the ellipsoidal spermatheca (pl. 16, fig. 9, *spth.*), 2.0 mm. in length by 1.3 mm. in diameter, which is joined close to its entrance by the more slender and longer duct of the spermatocyst, (pl. 16, fig. 9, *spc.*). The latter organ is of the usual pyriform shape, about 0.8 mm. in diameter and 1.5 mm. in length. No connection of the vagina with the oviduct exists, save through the external vaginal opening into its common exit close to the duct of the nidamental gland complex.

Bergh (1903, pl. 3, fig. 67) figured the vagina of his "*Pl. plumula*" as pyriform in shape, dilated proximally, and receiving as widely separated ducts the conduits of the spermatheca and spermatocyst. Unfortunately this is the only figure that he gave of the reproductive organs of this species. Vayssi  re gave no details for it, and Lacaze-Duthiers (1859, pl. 10, fig. 5) for "*pleurobranchae orange*," presumably *Berthellina engelii*, gave a generalized figure and stated that the vagina formed a cul-de-sac, terminating blindly and receiving on its anterior border toward its extremity two pyriform vesicles with unequal ducts.

### Genus *Pleurobranchus* CUVIER

*Pleurobranchus* CUVIER, 1805. Ann. du Museum, vol. 5, pp. 266-277. Genotype, *Pleurobranchus peronii* Cuvier.

### *Pleurobranchus digueti* Rochebrune

Plate 14, figures 1-16; plate 16, figures 10, 11

*Pleurobranchus digueti* ROCHEBRUNE, 1895. Bull. Mus. Nat. d'Hist. Nat. Paris, vol. 1, p. 240. PILSBRY, 1896. Man. Conch., vol. 16, pp. 201-202, pl. 54, figs. 98, 99, 1, 2. VAYSSI  RE, 1898. Ann. Sci. Nat. Zool., ser. 8, pp. 345-346.

*Bouvieria digueti* (Rochebrune), ODHNER, 1936. Further Zool. Results Swedish Antarctic Exp. 1901-1903, vol. 2, no. 1, p. 22.

The description of Rochebrune, based upon a specimen collected by Digu  t at Mogote, Bay of La Paz, Lower California, in 1895, is as follows:

"Corpus rotundato ovatum, turgidum; pallio ovato, antice sub-truncato, marginibus undatis, latis; pede subangusto, circulariter crenulato; regione buccali proboscidea; tentaculis duobus, rotundatis canaliculatis; branchiis subasconditis; superne miniaceum; inferne albo luteum.

"Long. - 0,022 mm. - Latit. 0,016 mm. - Crass. 0,012 mm.

"Diff  re du *Pleurobranchus patagonicus* d'Orb. (Voy. Am. M  r. Moll. pl. XVII, fig. 4 et 5) par son corps ovale, arrondi et non quadrilat  re; par son pied   troit, ne d  passant pas le autres parties du corps; par sa t  te proboscidiforme et non arrondie;



par ses tentacules ronds, non aplatis; par ses branchies en part cachées, ne dépassant pas les bords du manteau, et par sa coloration."

Pilsbry (1896) amplified this description somewhat from a specimen collected by W. K. Fisher at La Paz, and gives four figures based upon it. Total length 26 mm., width 18 mm. or more, altitude 11 mm. The mantle is wider than the body, amply projecting on all sides; the anterior margin of the foot bilabiate, its tip projecting beyond the mantle behind. The gill rachis bears a tubercle at the insertion of each of the twenty bipinnate plumules; anus behind posterior insertion of gill; the shell is small, situated entirely in front of the middle of the body, nearly flat, calcareous and moderately strong, purplish white. Earlier portion convex, terminating in a minute spiral, later portion becoming flattened, with flaring margins. Surface closely wrinkle-striate. Altitude 5.2 mm., width 4 mm. Jaws large, component plates of the tessellation without trace of lateral denticulation. Teeth of the radula simply hooked, with no denticles.

I have had for study two specimens of this species, collected by E. F. Ricketts in the Gulf of California, one having been taken at Cape San Lucas beneath rocks at low tide on March 18, 1940; the second and larger at Point Lobos, Espíritu Santo Island, off the Bay of La Paz. These were designated by the collector with the Numbers 4 and 5.

The length of the larger specimen in formalin was about 33 mm., its width 23 mm., and its height 13.5 mm. Both were much contracted and deformed by the preservative. This larger specimen, Number 4, was taken for dissection.

*Mantle* soft, covered with large, low tubercles, the smaller specimen smooth in the median area, the low soft tubercles becoming evident toward the margins. The median area shows traces of faint hexagonal markings about 1 mm. in diameter. Ground color of dorsum dull pink, clouded and mottled with darker vinous red to reddish brown. Margins wide, extending slightly beyond the edges of the foot, the anterior margin strongly contracted and probably slightly emarginate.

*Foot* wide, 23.4 mm. in maximum width, the tip of the rounded tail contracted and projecting slightly beyond the mantle margin, a strongly marked caudal gland area present in the mid-line slightly in advance of the tip, its length 5 mm. and breadth 2 mm. Anterior margin of foot deeply bilabiate, the upper lamella much thinner than the lower, the anterior angles rounded, not prominent. Dorsal surface of foot reaches 2.5 mm. in width, thickly set with irregular reddish brown markings extending back over the tail and in front continued above the frontal veil and the rhinophores.

*Rhinophores* short, cylindrical, close together, and united basally. Each consists of an inrolled plate with undulating margins. The upper inner one is closely inrolled, the lower outer margin broad and flattening out laterally, its edge continuous with the body below and flaring out distally into a somewhat campanulate extremity. Color of rhinophores dull brownish red, somewhat darker than the deepest mantle coloration.

*Frontal veil* not prominent, broadly notched in the median line, its edges thickened and rounded, the angles blunt, auriculate, the groove extending from the tip along the lateral edge nearly to the base of the veil. Width of veil one-half to two-thirds that

of the anterior end of the foot. Dorsal and ventral surfaces of the frontal veil vinous red, the upper surface mottled with darker blotches of the same color, the lower surface more uniformly dull red.

*Mouth* in median line close above the foot. In the large specimen the pharyngeal bulb is almost completely everted, exposing the large golden-yellow mandibular plates and the nearly colorless radula.

*Gill* completely concealed by the right mantle margin, bipinnate, with about twenty pinnules, 15.5 mm. long in the larger specimen, its tip free from the body for about 3 mm. Rachis of gill with a double row of alternating tubercles above and below, each borne at the base of a pinnule at its union with the gill stalk.

*Gland of Bourne - prebranchial sac.* External opening an inconspicuous foramen leading into a small sac with plicated glandular walls a short distance in front of the anterior end of the gill and behind and above the genital openings.

*Anus* just above the posterior end of the gill mesentery, where this is attached to the body wall.

*Renal pore* minute and inconspicuous, a short distance in front of the anus.

*Reproductive openings* on right side immediately in front of the gill, surrounded by a low integumental fold somewhat higher in front than behind. In the larger specimen the openings are everted, in front the elongate, conical glans penis is entirely exposed, curved backward to a blunt point. Upon the anterior median line of the base of the glans, a rounded, flap-like expansion is borne (pl. 16, fig. 11), which extends forward, then downward and backward. Close behind the glans are the everted openings of the vagina and oviduct. (Pl. 16, fig. 10.)

*Shell* small, nearly flat, translucent, delicate, situated anteriorly, overlapping the anterior border of the liver and the hinder portion of the pericardium, slightly to the left of the median line. In the larger specimen it measures 5.1 mm. in length by 3.5 mm. in width, and is almost entirely membranous, the calcified portion having been almost entirely dissolved away. In form it is substantially as figured by Pilsbry (1896, pl. 54, fig. 3). In the smaller specimen the calcareous portion of the shell is in very small fragments, but the largest of them shows distinctly the ridge-like growth lines.

#### EXTENDED ANATOMICAL DESCRIPTION.

*Mandibles* approximately rectangular in outline, elongate, the dorsal margin slightly convex, the ventral one somewhat concave, the posterior end rounded, the anterior one worn and irregular. (Pl. 14, fig. 5.) Each mandible is borne in a deep pocket of the pharyngeal integument, lined with epithelium, a narrow band of the anterior end being alone exposed and functional.

The anterior end of the mandible terminates in a deep transverse groove of the integument, in which the basal cuticula of the organ continues forward as a part of the general cuticula of the oral tube and mouth opening.



The posterior end of the mandible recurves outward in a deep groove formed by the bottom of the epithelial sac which produces it. Dorsally and ventrally this groove is continued forward as an extension of the matrix, being somewhat deeper on the dorsal than the ventral border.

Figures 10 and 10a of plate 14 represent the relations of the mandible as seen in longitudinal and cross sections under low magnification. In figure 10, the exposed and functioning part of the mandible is represented. The total length of the mandible of a large specimen is 5.6 mm., its width 4.2 mm.

Each mandible is composed of a great number of elements, the youngest at the posterior end, where they are formed in the matrix groove and become further developed toward the anterior end, where in the exposed portion they become worn through use and finally drop away. The platelets are of the shape characteristic of the Pleurobranchinae, in surface view somewhat slipper-shaped elongate-rectangular, with a broad, strong, pointed cusp at the anterior end. (Pl. 14, figs. 6 to 9.) Close behind the apex of the cusp on either side is borne a series of from one to four small, pointed denticles, the largest nearest the tip of the cusp, the others decreasing progressively in size behind it.

The dorsal surface is somewhat convex, with rather sharply defined lateral margins the posterior border is slightly concave and its angles are produced as rounded elevations which fit into corresponding depressions in the side and in front of the transverse process of the next adjacent tooth on either hand.

Slightly behind the middle of each element a transverse truncated process is borne, extending obliquely downward beneath the cusp of the next platelet beyond, and in the same transverse row. (Pl. 14, fig. 9.) These lateral processes of each platelet are opposite each other in the median two-thirds of the mandible width, but become less so as the margin is approached, the process of the upper side shifting slightly in advance of its fellow on the opposite side and rendering each element asymmetrical and causing an obliquity in the otherwise transverse rows. In addition the lateral plates, and especially those close to the margin, become more slender and rudimentary, departing widely from the form typical of those in the median areas of the mandible.

In side view of the mature element (pl. 14, fig. 9) the basal portion is seen to be made up of distinct layers which decrease in area progressively to a rounded base, it thus having somewhat the form of an inverted, truncated, laterally compressed pyramid, or a short ridge. This attains its greatest development in the anterior portion of the mandible matrix as successive layers are added to it from below.

This basal portion of each platelet is imbedded in a transparent basal cuticular layer which reaches its greatest thickness at the anterior end of the mandible and thins away posteriorly, becoming reduced to a very small amount and disappearing before the zone of the youngest teeth is reached. This common basement membrane is invisible in ordinary preparations and is usually stripped off in macerations with dilute potassium hydroxide so that the platelets may be readily pulled apart. Longitudinal and transverse serial sections in celloidin, with such stains as Iron Haematoxylin and Picro-Fuchsin, or Heidenhain's "Azan," reveal clearly the structure and relationships of the

elements to each other, to the common basal cuticula, and to the germinal epithelium from which they arise.

Vayssi re (1898, p. 240) is clearly in error when he states that the elements rest upon a semicartilaginous layer of connective tissue. The basal cuticular layer bears the same relationship to the platelets as was shown by me (1918, p. 313) for homologous structures in *Dolabella*. Beneath the mandible is fibrous connective tissue and the muscle layers of the pharyngeal wall.

In the mandible of a fairly large specimen some 77 transverse rows of platelets are present with approximately 40 in each row, a total of 3080 plates for each mandible, the number varying in different specimens. Vayssi re recorded 40 to 70 rows for *Bouvieria* and *Pleurobranchus* and 90 to 100 for *Berthella*, *Susania*, and *Oscanius*, the total numbers of the platelets ranging from 1200 to 3150 for *Bouvieria*, 2800 to 4200 for *Pleurobranchus*, more than 5000 for *Berthella*, and from 6000 to 7000 for *Susania* and *Oscanius*.

The elements are arranged in transverse rows, united by the tips of their lateral processes, thus leaving an interval between each two platelets which is filled in front by the hinder part of an element in the preceding transverse row, and behind by the anterior end of the platelet in the following row.

According to Pilsbry (1896, p. 201), who seems to be the only previous student of the details of the mouth parts of *Pl. digueti*, the cusps of the platelets are smooth, not denticulate, but they are unmistakably so armed in my material.

*Mandible development.* The earliest stages of formation of the mandible plates are found at the bottom of the epithelial sulcus containing the posterior end of the mandible, and later ones progressively from it toward the front. (Pl. 14, figs. 10-16.)

Figure 10 represents a low-power magnification of a longitudinal, horizontal section of the mandible, the inrolled sulcus at the left containing the youngest portion, the furrow at the right the oldest, anterior end, the mandible being represented by the broad dark band. Above the mandible is the margin of the pocket inclosing it, and further above is a fold of the radula. Figure 10a of the same plate shows a transverse section through the posterior half of the mandible.

The epithelium of the lining of the mouth is invaginated to form the pocket inclosing the mandible, the elements of which are formed by a differentiation of the cuticle of its outer wall. At the apex of the sulcus, the inner epithelium is doubled back to form the outer wall of the pocket in close contact with the outer face of the mandible, and extending forward to the margin of the pocket, where it becomes continuous with the mouth epithelium.

The epithelium of this outer wall is made up of small, low, cuboidal cells, polygonal in surface view and developing a strong cuticle as the top of the pocket is neared. Near the bottom of the pocket or sulcus (pl. 14, fig. 11) the cells increase rapidly in height, their small compact nuclei become elliptical, larger, and vesicular, and at the tip of the fold the cells become transformed into elements of fairly gigantic dimensions, elongated lengthwise of the mandible.

At the bottom of the sulcus a short, broad, cuticular cone is developed upon the anterior end of the cell, forming the apex of the future cusp of the developing platelet (fig. 11). Close behind it, likewise, appear a series of minute cuticular cones which will form the denticles. A delicate line of cuticle next appears, covering the surface of the cell, and soon unites with the cusp and its denticles. Progressive stages of this are seen in figures 11 and 11a which represent the mandible matrix under moderate magnification. New basal cells are added at the bottom of the sulcus and growth carries them around beyond the loop.

The cuticle thickens progressively, as is well shown in cross sections of the mandible represented in figures 12a, 13a, 13b, in which each cell is shown capped by a layer of cuticle which arches over the rounded cell surface and grows down laterally. Similar stages are seen in longitudinal section in figures 12 and 13. The cells show a distinct basal fibrillation, the nuclei are large and vesicular and crowded with minute chromatin granules, but the fixation of the present material does not warrant conclusions as to minute cytological details.

As the exposed margin of the mandible is approached, the matrix cells tend to flatten and the layers of the bases of the elements increase from within and below. In this flattening the rounded cupola-like dorsal surface of the cell becomes lower and an irregular space of varying size and extent remains unchitinized in the central part of each element as the cytoplasm retracts. This is recognizable in mandible mounts of the older plates at times by blackening, possibly through pigment, or granular debris, or entrapped air. (Pl. 14, figs. 14, 14a, 15, 16.)

The first appearance of the common basal cuticula may also be recognized between the bases of the elements, binding them together. At a definite zone across the mandible at a short distance behind the free area, the nuclei of the basal cells condense into darkly staining structures and apparently the cells multiply by direct division resulting in a rapid increase in their number and a corresponding decrease in size, so that several may be seen to underlie each element, instead of as at first a single giant cell. (Pl. 14, fig. 15.) The platelet has now reached its full size and the deposition of the common basal cuticula rapidly increases. Just opposite the margin of the outer epithelial sheath the basal epithelium layer decreases in thickness, its constituent cells multiply, and it takes on the appearance of the general epithelium of the mouth with which it becomes continuous at the anterior end of the mandible. (Pl. 14, figs. 15, 16.)

A slight decrease in the over-all length of the mandible elements in passing from the mature younger to the oldest elements at the anterior margin is noticeable, aside from that due to the wearing away of the tips of the cusps. The longest platelet, measured in surface view from the younger region, was 0.24 mm. in total length, while that at the anterior end was 0.18 mm.

*Radula* very pale yellow, nearly colorless, broad, of a square shape, 9.0 mm. maximum width by 9.0 mm. in length when flattened out.

Teeth in 89 rows of which the first 26 show signs of wear, the most anterior of these being thus reduced to but a few teeth in a row.

Rachis very narrow, naked, the lateral teeth simple, closely set hooks, the smooth pointed tips directed slightly and obliquely inward.

The teeth are of fairly uniform size, the bases narrow, slightly expanded on their inner margins. A typical tooth from near the middle of a row (pl. 14, fig. 1) stout and strongly hooked, its vertical height from base to tip reaching 0.120 mm.; the innermost teeth (pl. 14, fig. 3) are somewhat smaller, but of the same form, the outer teeth becoming progressively more slender, smaller, and more erect (pl. 14, fig. 2), but scarcely rudimentary.

The number of teeth in each half row reached 170 as a maximum, so that the dental formula may be indicated as 89 (170.0.170) in a specimen of 32 mm. length. The teeth are borne upon a relatively thick basal layer of chitin, shown in the sectional view in plate 14, figure 4.

*Reproductive system.* (Pl. 16, fig. 10.) The *ovotestis* covers the upper surface of the liver. From it the *hermaphroditic duct* arises by the union of branches from each lobule, passes forward and outward beneath the intestine to the anterior genital complex where it dilates into the *hermaphroditic ampulla* (*h. a.*) which is looped into a close series of turns upon the outer posterior border of the complex. It is about 16 mm. long and 0.45 mm. in diameter. Its distal end narrows into a short duct which gives off the slender *vas deferens* (*vas. d.*) and continues as the *oviduct* into the *nidamental-albumen gland mass*.

The *vas deferens* (*vas. d.*) passes into the ovoid prostate gland (*pr.*) on the ventral face of the complex. The prostate, 3.2 mm. in diameter by 1.7 mm. long, is divided into two nearly equal lobes by a deep constriction. Close to the entrance of the *vas deferens* into the prostate, it emerges as a continuation, at first a thick-walled, apparently glandular segment 0.32 mm. in diameter and some 5 mm. in length. It then continues as a greatly convoluted thinner segment 0.18 mm. in diameter, with a muscular wall. Near the base of the *glans penis* (*p.*) it dilates into a thin-walled third segment, 0.03 mm. in diameter and 3.0 mm. in length, which passes into the base of the *glans*, tapers gradually, and opens externally at the tip.

The *glans penis* is conical, curved slightly backward and tapering to a blunt end. Its basal diameter is 1.4 mm., its length 6.4 mm. At the anterior surface of its base upon the median line is borne a flattened, wing-like expansion which curves downward and backward (pl. 16, figs. 10, 11). Surrounding the base in front and below is a low integumental fold, finely and deeply pigmented on its outer surface.

Immediately behind the everted *glans* are the separate but contiguous openings of the *vagina* and the *oviduct*. The *vagina* has a length of 10 mm., passing inward from the opening at first in a relatively straight course, then becoming more sinuous and receiving the very short common duct of the *spermatocyst* (*spc.*) and the *spermatheca* (*sph.*) and continuing as the relatively straight vaginal duct into the lumen of the *nidamental-albumen gland complex* close to the entrance of the *oviduct* (*ov.*).

The *spermatocyst* (*spc.*) is a long, slightly dilated, rounded tube ending blindly, about 10 mm. long and 0.8 mm. in diameter, narrowing to a short duct at its distal

end as it joins the duct of the spermatheca close to the union of the latter with the vagina (*v. d.*). Its wall is thin and its lumen is closely packed with spermatozoa. This elongate tubular form departs markedly from the usual pyriform shape of the spermatocyst as described and figured for other Pleurobranchinae. So far as I am aware a similar condition has thus far been recorded only for *Susania* "*testudinaria*" (more correctly *testudinaria*) Cantraine 1840, as illustrated, but not described by Vayssi re in 1906 (pl. 27, fig. 184).

Bergh (1897, p. 89, pl. 12, figs. 11, 12) showed a similarly elongate spermatocyst in *Oscanicella* [= *Pleurobranchus*] *purpurea* var., but held that most of it is a greatly elongated duct, the spermatocyst forming solely the terminal slightly dilated portion. This is clearly not the case in *Pl. digueti*, the duct proper being quite short and the bulk of the thin-walled tube being filled with sperm.

The short and narrow duct leads to the *spermatheca* (*sph.*), a spheroidal thin-walled sac, 4.5 mm. in greatest diameter, and filled with the usual contents of cellular debris and sperm.

### ***Pleurobranchus californicus* Dall**

Plate 6, figures 1, 2; plate 13, figures 35-37

*Pleurobranchus californicus* DALL, 1900. The Nautilus, vol. 14, pp. 92-93.

The original description of this species is as follows:

"*Pleurobranchus californicus*, n. sp.

"Animal, when fresh, of a waxen white, with a surface apparently smooth, or rather like the skin of an orange, not tuberculate, but, under a glass, showing obsolete distant pustules hardly raised above the general surface; body elongate-oval, the foot longer than the mantle behind. The gill short, its stem granular, not tuberculate, with ten or eleven alternate short vanes, the whole adnate nearly to the tip, medially situated, with the contiguous genital orifices just in front of its anterior insertion and the anus just over the posterior insertion between the gill and the mantle. Eyes, rhinophores, muzzle, jaws and teeth, as described by Pilsbry, [1896, pp. 201-202], for the Gulf of California species collected by Fischer (Man. Conch., xvi, pp. 201-2). Shell rather long and narrow, subrectangular, longitudinally obsoletely striate on the left side, obscurely obsoletely punctate near the anterior edge, and covered with a very thin periostracum which reflects nacreous tinges of color. The shell itself is white and thin, with a small spiral nucleus; the left margin somewhat recurved, the central part moderately convex; the whole extends more than half the length of the body and measures 12 by 6.5 mm."

The specimen upon which the species was based by Dall (1900) was collected at San Pedro, California, by Mrs. Ida S. Oldroyd, late Curator of Conchology, Department of Geology, Stanford University. The shell was evidently returned to Mrs. Oldroyd. The animal in alcohol was sent to Bergh for anatomical study. A brief account of his results was given by the latter (Bergh, 1902, pp. 379-380, Bd. 1, pl. 1, figs. 24-26), the



species being transferred by him to the genus *Oscaniella* Bergh, 1897. *Oscaniella* is regarded by Odhner (1926), and by Thiele (1931), as a synonym of *Pleurobranchus* and is here so considered.

The following details of the anatomy of *Pleurobranchus californicus* are taken from the account by Bergh (1902, pp. 379-380).

*Body length* 21 mm., its width 13 mm., its height 9 mm. The gill length 10 mm., its width 3.5 mm., the plume made up of about 25 pinnules on each side of the rachis which bears a double row of alternating tubules at the base of the pinnules, owing to the dilation of the branchial veinules as they join the branchial vein.

*Genital openings* simple, without guarding folds of the integument. Caudal gland about 3 mm. in length.

*Pharyngeal bulb* short and broad, 3.5 mm. in length and breadth, the mandibles strong, citron yellow, as long as the bulb, rather high; length of the mandibular platelets ranging up to 0.08 mm., their height and width up to 0.035 mm., the cusp entirely smooth.

*Radula* colorless, the teeth colorless, hooked, in 110 rows, a very large number in each row. The basal length of the four outermost teeth ranged from 0.025 mm. to 0.037 mm., while that of the largest tooth in a row was 0.06 mm., the height of the hook the same. Bergh's figures of the mandible platelets and the radula teeth are reproduced on plate 13, figures 35, 36, 37 of the present paper. Their dimensions do not correspond to the magnifications stated by him. No details are given regarding the reproductive organs. The species is held by Bergh to resemble those of *Pleurobranchus* more closely than other species of the genus *Oscaniella*.

The paleontological type collection of Stanford University contains the type of Dall's species. The tray containing it is numbered 6272 and contains two shells, the larger of which corresponds to that described by Dall. The tray label reads:

No. 6272

Syntypes

*Pleurobranchus californicus* Dall

San Pedro, California.

Reference: Nautilus, vol. 14, no. 8, 1900, p. 92.

Identified by W. H. Dall.

Collector, I. S. Oldroyd.

Another label in the tray reads - "*Pleurobranchus californicus* Dall. Type, Whites Point", evidently in Mrs. Oldroyd's handwriting.

A third label in a different handwriting reads: "*Pleurobranchus californicus* Dall, San Diego, Cal." C. W. Gripp, San Diego. On the reverse is written, "Large one is the type."

The larger shell agrees with Dall's description upon which it is evidently based. Plate 6, figures 1 and 2, show the photographs made by the author. The shell is mounted on the tray ventral side upward (fig. 2) the inner surface showing strongly marked

growth zones in the form of thickened ridges. A few faint longitudinal striae radiate out from the region of the spire toward the right side of the shell, dying away before the margin is reached. Three minute pearl-like bodies are upon the inner surface, in its anterior portion.

The smaller shell (*Pleurobranchus strongi*, pl. 6, fig. 5) is mounted with the dorsal surface uppermost; its periostracum is light brown reflecting nacreous tinges of color in the low ridges of its surface. Under a high power ( $\times 58$ ) and strong reflected illumination, the surface is marked with fine punctulations rounded or elongated and arranged in rows corresponding to growth striae. Similar markings are shown by shells of Monterey specimens mounted in clarite, a strongly refractive medium.

The two shells are evidently not of the same species and cannot be syntypes. The larger one tallies exactly with Dall's description, and is evidently the holotype of Dall's species. The second and smaller shell is probably the one referred to on the C. W. Gripp label, and is not *Pleurobranchus californicus*. It agrees with *Pleurobranchus strongi*, new species, described later, which has been taken from Monterey Bay to San Diego.

A specimen of *Pleurobranchus* was taken by Mr. and Mrs. E. P. Chace at Crescent City, California, and was described briefly by Burch (1944) and given the new name of *Pleurobranchus chacei*. Based upon the meager description, the present writer expressed the opinion to Mr. Burch that the shell in question was more probably *Pleurobranchus californicus* and was so given by him in the Minutes of the Conchological Club of Southern California, No. 37, 1944, pp. 17-18.

In 1946, careful comparison of the shell of *Pl. chacei* sent to the California Academy of Sciences by Mr. Burch, as the type, was made with the two shells of the Oldroyd collection. It closely resembles the larger of the two on the type tray of *Pl. californicus* Dall. From this comparison it is evident that *Pl. chacei* is a synonym of *Pl. californicus* Dall.

#### ***Pleurobranchus californicus denticulatus* MacFarland, new subspecies**

Plate 5, figures 1-5; plate 13, figures 25-34; plate 16, figure 12

The form here described as a new subspecies of the preceding species is of rare occurrence in the Monterey Bay region. From the first specimen, collected at Point Pinos in 1894, the figures reproduced on plate 5 were made. Detailed anatomical studies were deferred until more specimens might be obtained. A second one was finally found in the Large Tide Pool, Point Pinos, in July, 1931, and a third one in November, 1932. The following account is based upon these.

In June, 1941, a small specimen was taken by Dr. F. A. Pitelka and kindly turned over to me for study. In all external characters it coincides with *Pleurobranchus californicus* here described.

*Body* elongate oval, somewhat arched, the back rounded, soft, covered with larger and smaller tubercles irregularly arranged, the largest about 0.5 mm. in diameter nearer the mid-dorsum, decreasing in size laterally.



*Mantle* ample, its undulating margin extending well beyond the foot laterally, in front with a deep and wide notch with a slight median prominence, beneath which the blunt, cylindrical, rolled rhinophores project.

*Foot* broad, truncate in front, the angles rounded, the margin bilabiate, the posterior end rounded, projecting beyond the mantle when crawling, its free dorsal surface finely tuberculate; *frontal veil* broad, rhomboidal, tuberculate, projecting well beyond the mantle, its outer anterior angles bluntly pointed, the outer anterior margin thin, the outer lateral margin grooved throughout. In crawling, the anterior margin of the velum is kept in constant undulating motion as if a tactile organ; *rhinophores* cylindrical, blunt, formed of a rolled plate, the margins of which are external, their bases close together in the median line, the inconspicuous *eyes* beneath the integument close behind the bases of the rhinophores.

*Gill plume* on right side, concealed between the mantle margin and the foot, proportionately large in the living specimen, its hinder one-third free from attachment to the body wall, bipinnate, the pinnules about seventeen to twenty in number, arranged alternately above and below the rachis. The pinnules are large and small, usually two smaller ones occurring between two larger ones, but not always. Each pinnule is made up of a double series of small flattened platelets along the axis of the pinnule. At the junction of each pinnule with the rachis, is a rounded tubercle, those of the upper and lower pinnules thus forming a double row along the whole gill axis, and along each pinnule a similar, much smaller tubercle marks the junction of each gill platelet with the pinnule. (Pl. 5, fig. 4.)

*Anal opening* close above and slightly behind the middle of the gill attachment.

*Reproductive openings* contiguous, close in front of the anterior end of the gill rachis, surrounded by low, inconspicuous folds of the integument. The glans penis is long, tapering, and pointed, at times visible beyond the low collar-like fold surrounding it.

*Color.* Ground color of dorsum, frontal veil, and top of foot deep cream, the larger and smaller tubercles of mantle, frontal veil, and dorsal surface of foot dead white; the peripheral portion of mantle, top of foot, and frontal veil sprinkled with minute white flecks; the distal halves of the rhinophores thickly sprinkled with white. Mantle and frontal veil narrowly edged with dead white, the sole of the foot cream.

*Dimensions, living specimens.* The largest taken in 1894 at Point Pinos; length 50 mm., width 29 mm., height 12 mm., gill length 36 mm. This specimen was used for the external description and colored figures on plate 5, figures 1-5. The smallest specimen, collected by Dr. Pitelka, had a length of 11 mm., width 8.8 mm., height 4.5 mm. This was studied alive.

*Alcoholic specimens.* The description of the largest is given in detail: length 40 mm., width 22 mm., height 12 mm., gill 17 mm. in length. The *head* was retracted,

*veil* truncate, 12 mm. wide, angles bluntly pointed. *Dorsum* firm with scattered low, soft tubercles, mostly retracted. *Gill plume* with 16 pinnules on the lower side, 17 on upper, its rachis with a double row of distinct tubercles. *Foot* broad, bluntly rounded, bilabiate, *tail* rounded. Under surface contracted, caudal gland not clear. *Shell* outlines not sharply visible through the dorsum. When exposed, 25 mm. long by 13.4 mm. wide. Growth lines strongly marked, ridges on the surface, apex depressed. Iridescent sheen near the apex; the shell extends forward to the rhinophore area. The shell was removed and preserved with the specimen.

Two specimens are recorded for 1911 and 1921 from Point Pinos. Also from Point Pinos, G. E. MacGinitie collected two fine specimens July 21, 1931, and November 26, 1932. The latter were taken for dissection. This had a length overall of 15.0 mm., width 10 mm., height 5.6 mm. The dorsal integument soft, almost gelatinous, thickly set with rounded and elliptical depressions with clear centers, surface between white. The calcified portion of the shell shows through the injured integument above it as dead white, but badly broken. The shell is slightly in advance of the mid-length of the body, thin, calcareous, elongated, broader in front. The calcified area slightly to the left of the middle of the body is glistening white and broken into many adherent pieces. It is somewhat triangular in form, widest anteriorly; the front margin is somewhat oblique from the left side forward to the right. The right border is slightly convex, extending obliquely backward and to the left to the rounded, narrow, posterior end. The left border is nearly straight and parallel with the side of the body. The apex could not be found. Surrounding the white calcified portion is a very pale, amber, translucent area of periostracum extending beyond the calcified zone on the right from one-third to one-sixth of the width of the shell. Shell sculpture finely and closely punctate near the apex, lines of growth distinct, in part ridge-like.

Length of calcified portion 4.8 mm., its maximum width 3.5 mm. in the animal of 15 mm. length of notum.

*Habitat.* Found in open pools at Point Pinos and Point Lobos, Monterey area, California.

#### EXTENDED ANATOMICAL DESCRIPTION.

*Mandibles.* The mandibles (pl. 13, figs. 25-34) are about twice as long as wide, darker anteriorly, the ventral and hinder borders rounded, the dorsal border straight. Mandibular elements arranged in some 58 to 60 transverse rows of 58 teeth, more or less. Those of each row alternating in position with those of the row immediately in front and the following ones as shown on plate 13, figure 34. The dorsal surface of each element is slightly convex, the pointed anterior cusp slightly raised above the level of the remainder of the surface. Upon either side, the cusp bears from one to five pointed denticles. (Pl. 13, figs. 26, 28.)

On each side the platelet bears a blunt transverse process below the level of its dorsal surface which comes in contact with a similar process on the adjacent element, the

union lying below the apex of the cusp of the element in the next adjacent row. (Pl. 13, fig. 34.) The lateral processes are nearly opposite each other in the mid-region of the mandible, but become less symmetrical toward the upper and lower borders, thus rendering the rows somewhat oblique rather than transverse.

The elements from near the middle line of the mandible range in length from 0.06 mm. at the anterior, oldest end, to 0.084 mm. at its posterior end, the width from tip to tip of the transverse process varying from 0.024 mm. to 0.03 mm. in the same regions, the dorsal surface of the platelet measuring from 0.012 mm. to 0.015 mm. in maximum width. Toward the dorsal and ventral margins the platelets become narrower and more irregular in form.

The hinder end of the mandible curves outward to the bottom of a deep groove in which the elements originate in a manner similar to that described for *Pl. digueti*. The whole mandible, except its most anterior exposed end, is included within the pocket of oral integument, a narrow anterior zone only being exposed for functional use, to be replaced by growth from behind as it wears away. Since the elements show progressive developmental changes from behind forward, it is only in the mid-anterior region that typical mature stages may be found, and these only should be used for comparative studies.

The dimensions here given agree approximately with those of Bergh, the most significant discrepancy being in the presence of one to four denticles on each side of the cusp, which, according to Bergh, is entirely smooth.

*Radula* (pl. 13) relatively small, pale amber in color, made up of about 66 transverse rows of hooked unciform teeth, with some 75 to 85 teeth in each half row, the rachis being quite narrow and naked. The dental formula of the specimens at hand may be expressed as 66 (75-85.0.75-85), though it must not be ignored that larger specimens, such as the one taken in 1894, will doubtless show a greater number of rows and of teeth.

The innermost tooth (pl. 13, fig. 32) is smaller than the succeeding ones which rapidly increase to a size uniform throughout the row save in the outermost (pl. 13, fig. 29) five or six which are smaller, the hook becoming gradually less curved and more erect in the outer part of each row. The base of each tooth is broadly expanded laterally as a flattened plate, extending toward the median line of the radula, the hook arising from near its outer margin (pl. 13, figs. 29, 30). The length of the bases of the four outermost teeth in a typical row ranges from 0.008 mm. to 0.011 mm., the height of the hook from 0.0016 mm. to 0.022 mm. The basal length of one of the largest teeth from the middle of a half row measures 0.027 mm., the height of its hook the same. These measurements are approximately one-third of those given by Bergh (1904) for similar teeth in *Pleurobranchus californicus* Dall, aside from significant differences in form.

## Lateral teeth measurements:

<i>Pleurobranchus californicus</i>	Base	Height
<i>vide</i> Bergh		
Outermost lateral	0.025 mm.	?
Second lateral	0.029 mm.	?
Third lateral	0.034 mm.	?
Fourth lateral	0.037 mm.	?
Largest lateral	0.06 mm.	0.06 mm.
<i>P. californicus denticulatus</i> , new subspecies		
Outermost lateral	0.008 mm.	0.016 mm.
Second lateral	0.008 mm.	0.018 mm.
Third lateral	0.011 mm.	0.019 mm.
Fourth lateral	0.011 mm.	0.022 mm.
Largest lateral	0.027 mm.	0.027 mm.

The form of the hook of these teeth as shown on plate 13, figure 29, is nearly straight and erect, being but slightly oblique and awl-like, while that shown in Bergh (1904, pl. 1, fig. 26), reproduced here on plate 13, figures 35 and 36, is quite different, being low and strongly curved. The height of the largest lateral noted by Bergh is 0.06 mm., its basal length the same; the height of the largest lateral in the Point Pinos specimen is 0.027 mm., the basal length being the same. Thus the teeth of *Pl. californicus*, as given by Bergh, are approximately two and one-half times the size of those found in the Point Pinos specimen, aside from significant differences. However, allowances must be made for differences in age and size of the specimens at hand, and for the range of variability in the teeth of Pleurobranchidae, concerning which but very little is known.

*Reproductive organs.* (Pl. 16, fig. 12.) The *ovotestis*, covering the front and right anterior face of the liver, gives off the *hermaphroditic duct* by the union of many branches from its lobules. This duct dilates at once into the long, cylindrical, hermaphroditic *ampulla*, 9 mm. long by 0.5 mm. in diameter (*h. amp.*) which passes forward to the inner, superior face of the anterior *genital complex*, narrows suddenly, and divides into the *vas deferens* and the *oviduct*. The first immediately enters the lobulated prostate gland, 2 mm. long by 1 mm. broad (*pr.*), and emerges from its distal end. Close to its exit it is joined by the short duct of the accessory prostate (*a. p.*), a blind tubular sac, 2.2 mm. long and 0.7 mm. in diameter, with thick walls of glandular epithelium. Beyond this junction the long and slender vas deferens is irregularly looped back and forth, close to and within the dilated proximal end of the *penis*, finally passing as a straight tube to its external opening at the tip of the *glans*. The everted *glans penis* (*gl. p.*) is long, cylindrical at first, and then tapers to a blunt point. It measures about 3.25 mm. in length, and is surrounded at its base by a low fold or collar of integument, 1.2 mm. high externally and 0.6 mm. internally to its point of union with the base of the glans. Its margin is thin, entire, and smooth. A part of this fold is undoubtedly the everted glans sheath.

The course of the *oviduct* (*ov.*) is not entirely certain in the dissection. After its origin by the division of the distal hermaphroditic duct it seems to pass directly to the spherical spermatheca, joining the *vaginal duct* as it enters. No trace of a spermatocyst, or second *vesicula seminalis* is to be found. The vaginal duct (*v. d.*) is long, describes two main loops, the one forward, the other backward, and dilating gradually into the *vagina* (*v.*), passes outward to its external opening close behind the base of the penis, in front of and slightly above the opening of the nidamental-albumen gland, the two openings being united by a shallow sinus with tumid margins in their partially everted condition. In a completely retracted state they may actually open into a common atrium. Thus it will be noted that the female branch of the hermaphroditic duct is entirely independent of the gland complex until the external opening is reached, a condition figured by Vayssi re for *Pl. forskali* and *Pl. perrieri*, and considered by him to be characteristic of the subgenus *Pleurobranchus* *s. str.* in general.

Just how the eggs become inclosed in their albumen-filled capsules and then united into the band-like nidosome is not clear, unless they pass back from the external vaginal opening into the duct of the nidamental-albumen gland to receive their envelopes before being finally laid. Lack of suitable material has so far prevented a further study of this interesting question.

Eggs were deposited in a coil on the aquarium dish by the specimen collected in 1894. (Pl. 5, fig. 5.)

This animal clearly belongs to *Pleurobranchus* *s. str.* In general features it resembles *Pleurobranchus californicus* Dall, though the dorsum differs in being distinctly tuberculate in life, but much less so in alcohol, especially if fully relaxed.

The gill rachis is described by Dall as being "granular not tuberculate." while this one bears a double row of tubercles. However, Bergh's brief study of Dall's specimen indicates that the rachis is actually tuberculate.

Radula measurements are distinctly larger in Bergh's description and, according to him, the cusps of the mandible elements are smooth, while in the Monterey specimens they bear one to four denticles. Bergh also records the presence of a pedal gland.

### ***Pleurobranchus strongi* MacFarland, new species**

Plate 6, figures 3-7: plate 15, figures 1-15; plate 16, figures 13, 14

*Body* elongate, oblong, somewhat flattened, soft, the broad mantle margin covering the foot everywhere except in front and behind, the anterior margin slightly concave, widely notched, fitting closely down around the head, the posterior margin smooth, the rounded end of the foot projecting slightly.

*Frontal veil* wide, formed by the fusion of the labial tentacles, broadly notched in the median line, outer angles triangular, lateral margins grooved lengthwise throughout, the front margin thin, undulated. (Pl. 15, figs. 12, 14, 15.)

*Foot* narrower than the mantle, its anterior end truncate, slightly bilabiate, the upper lip thin, the angles rounded, the tail scarcely projecting beyond the mantle in the alcoholic specimen, edges thin, caudal gland present, large, 3.5 mm. long, 2 mm. wide.

*Gill plume* on the right side, short, concealed between the mantle margin and the foot, its rachis smooth, without tubercles, bipinnate with 16-20 pinnules, 7.3 mm. long, its posterior half free from attachment to the body wall. (Pl. 15, fig. 13.)

*Anal opening* just above the end of the gill attachment.

*Reproductive openings* close together, immediately in front of the gill, surrounded by a low thickened fold of its integument, continuous above, in front and below, and interrupted behind.

*Rhinophores* cylindrical, blunt, directed forward, outward, and upward, united at their bases in a median line above the velum, each a flattened plate inrolled from both margins. The anterior margin is somewhat thinner than the posterior one, and is prolonged laterally beyond the base of the rhinophore along the side of the head, terminating in a free angular lobe. (Pl. 15, figs. 14, 15.)

*Eye* small, black, located at the base of the rhinophore.

*Color.* Dorsum pale yellow, finely punctate, with darker yellow as seen under magnification of 14 $\times$ . The surface finely tuberculate, a series of fairly regularly arranged tubercles toward the margin; their central core being a lighter yellow, the outer part of each tubercle apparently translucent amber. Under strong, oblique illumination and a magnification of 20 $\times$ , these tubercles are seen to form the center of faint hexagonal areas, the largest being low blunt cones with a central lemon-yellow spot. The elevated surface and tips of these are dusted with extremely fine sprinklings of dark yellow which is responsible for the above-noted amber appearance. The central area of the dorsum has smaller, fewer, and more scattered tubercles. The dorsal surface of the foot is similar to the dorsum, the ventral pale yellow. In alcohol practically all color disappears, leaving the animal pale yellow. The foregoing description was made from live animals collected in 1931 and 1932 at Point Pinos.

*Dimensions.* Length 19.5 mm., width 12.2 mm.; length 18.4 mm., width 12.6 mm., height 6.6 mm.; length 15.5 mm., width 11.4 mm., height 7.2 mm.

*Shell.* A shell was removed from a specimen of the Strong collection, and found to measure: length 12.5 mm., width 9.7 mm., height 5.8 mm. A permanent mount was made in dammar, the dislodged rim mounted separately. (Pl. 15, figs. 1, 2, 3.) The measurements of the shell vary owing to the irregular margins and the absence of the rim. (Pl. 6, figs. 3, 4.) The length of the mounted shell is 6.4 mm., width 4 mm., height 0.8 mm. The added rim gives a total length of 7.5 mm. This shell is thin, delicate, with periostracum translucent, opalescent, elongate, rectangular, placed somewhat forward of the middle of the body. Umbo small, spire near the left posterior margin, the left side being straight, the right nearly so, the ends rounded. (Pl. 15, fig. 1.) The



sculpture of the surface was closely studied and all lines drawn with a camera lucida. The growth lines are strongly marked, finely sculptured in the older portion; fine spiral lines radiate from the umbo region and cross the lines of growth, visible only under magnification. Fine longitudinal lines, well marked near the apical region, become indistinguishable in the outer margin. The innermost portion of the spire but slightly arched, the outer whorl becoming much flattened, thinning away at the edge. The growth lines of the outer whorl, from below, become quite strong, and the successive layers are irregularly thickened, giving the surface a ridged appearance; crests formed by these irregularities catch the high lights with deep shadows between. (Pl. 15, figs. 1, 2, 3.) Mounts of shells were made from specimens collected at Point Pinos, Monterey Bay. (Pl. 6, figs. 5, 6, 7.) Brief descriptions are here given:

Figure 5. Specimen 19.5 mm. in length, 12.2 mm. in diameter. Collected by G. E. MacGinitie, July, 1932. Shell 8.5 mm. in length, 5.5 mm. in width; elongate, elliptical, much flattened, with fragile and broken margins. Umbo at the lower left, inconspicuous and flattened. The displaced spire partly visible, the surface smooth, nacreous, one full turn. The calcareous portion nearly white, its marginal portion crumbling, the thin, transparent periostracum extending beyond it. Growth lines are very pronounced, forming irregular surface ridges; no longitudinal lines visible, shell slightly iridescent.

Figure 6. Specimen 18.4 mm. long, 12.6 mm. wide, 6.6 mm. high. Collected by G. E. MacGinitie, July, 1931. Shell 11 mm. in length, 6.8 mm. in width. The largest shell was mounted: it covered the entire visceral mass. White and thin, the small spiral nucleus on the posterior left margin somewhat recurved, central portion moderately convex. The anterior margin broken, all fragile, periostracum very thin, reflecting nacreous tinges of color. Growth lines are very distinct: fine horizontal lines radiate from the umbo region.

Figure 7. Specimen 19.5 mm. in length, 12.2 mm. in width. Collected by Miss Betty Blagg in 1941. Shell 8.5 mm. in length, 6.5 mm. maximum width. Shell oblong, oval, the margins very thin, fragile, and broken. Apex in a minute spiral of some two turns obliquely placed upon the posterior margin of the broad outer whorls which become more flattened. Surface of apical region smooth, the outer whorls with strongly marked lines of growth crossed by fine longitudinal lines, closely set and more distinct in the apical area, becoming more obscure toward the margin.

*Habitat.* Taken occasionally in rocky tide pools at extreme low tide upon or near compound ascidians at Point Pinos, Monterey Bay, Point Lobos, and Carmelo Bay. A single specimen was taken at Cabrillo Point in 1921. A specimen taken at Santa Cruz Island, off Santa Barbara, was kindly sent to me by Dr. W. G. Hewatt. Numerous specimens were taken at White's Point, San Pedro, in 1921, by A. M. Strong. At Point Pinos, Monterey Bay, were taken the following: two specimens in July, 1931, one specimen in July, 1932, by George E. MacGinitie; also one at Pescadero Point by him. In August of 1941 Miss Blagg found one fine specimen. These all have furnished material for the foregoing descriptions.

It has not yet been taken by dredging, which is not surprising when one considers its habitat between and beneath overhanging rocks, where it can scarcely be reached by such means. It will undoubtedly be found to have wider distribution.

This species is distinct from any heretofore described from the West Coast of America, as well as from European and Pacific forms. I take pleasure in dedicating it to the late Mr. A. M. Strong of Los Angeles, who has done much to extend our knowledge of Pacific Mollusca, and to whom I am indebted for several specimens of this species.

#### EXTENDED ANATOMICAL DESCRIPTION.

*Mandibles* (pl. 15, fig. 4) small, pale amber, darker toward the front margin, the ventral border straight, the dorsal strongly convex, the posterior border rounded. The ventral borders of the two mandibles are in close proximity in front, becoming more separated behind; dorsally they are widely separated, the mandibles occupying the lower part of the walls of the anterior pharyngeal bulb. Length of mandibles over all 1.6 mm., their maximum width 1.3 mm., the extreme anterior end only being reflected backward. The mandibular elements are arranged in a regular tessellated pattern, the anterior end bearing a pointed cusp elevated slightly above the level of the plate and directed forward. (Pl. 15, fig. 6.) The cusp (pl. 15, fig. 7) typically bears three pointed denticles upon each side, the pair nearest the tip the strongest, the following pairs decreasing in size progressively. Near the upper border of the mandible the elements become reduced to flattened plates. Length of typical platelet 0.027 mm., the length varying but slightly throughout the adult mandible. (Pl. 15, figs. 5, 6, 7.)

*Radula* (pl. 15, figs. 8-11) small, 1.7 mm. long by 0.6 mm. wide in a large specimen. Rachis very narrow, naked, lateral teeth small, simple, erect hooks of quite uniform size and shape, the outer 10 of each half row decrease progressively in size, the outermost (pl. 15, fig. 9) becoming quite small and rudimentary, the innermost lateral somewhat smaller than the adjacent ones. (Pl. 15, fig. 8.) Transverse rows of teeth with 45 to 55 in each half row. Vertical height of a typical lateral tooth .027 mm., length of its base .026 mm. Base of typical tooth somewhat kite-shaped, with broad rounded anterior end tapering behind to a point. The cusp arises vertically from the anterior portion of the base nearer its outer margin than its middle. (Pl. 15, figs. 10, 11.)

*Reproductive system.* The ovotestis covers the upper and anterior surfaces of the liver, with which it is closely united, in a fairly thick layer. From its lobules small ducts unite into larger ones which coalesce into the rather slender hermaphroditic duct, leading forward from the anterior end of the gonad and dilating into the elongated whitish hermaphroditic *ampulla*, about 0.5 mm. in diameter and 8 mm. in length. (Pl. 16, fig. 13.) This figure represents the relations of the ducts in the anterior *genital complex*, as spread out in dissection. The albumen and mucous glands have not been represented

save as concerns the relation of the vaginal duct and the external opening of the *vagina*. Looping across the dorsal and inner posterior borders of the anterior genital complex, the hermaphroditic ampulla passes obliquely outward and forward, narrowing, and dividing into the slender *vas deferens* and the *oviduct*. The vas deferens at once passes into the proximal end of the prostate gland, a somewhat crescentic, lobular mass occupying the middle of the upper face of the complex. From its distal end the vas deferens emerges as a slender duct, describes a short angular loop forward, and then passes into the base of the *preputium*. Close to its entrance it is joined by a slightly stronger duct which leads from an irregularly convoluted *tubular appendage*, 0.4 mm. in diameter, and about 1.5 mm. long, lying upon the anterior face of the complex and terminating blindly in a blunt end. Its wall is thick and made up largely of glandular cells. It corresponds to what is figured and described by Vayssière (1898, pl. 27, fig. 180) for *Berthella brocki* as an accessory prostate gland.

Within the preputium is the short, conical *glans penis*, tapering rapidly to a pointed extremity, shown in the retracted condition in plate 16, figure 13. No trace of an armature of any kind is present. Surrounding the base of the glans penis, externally, is a low collar-like fold of the body integument. This does not form a closed wall but is interrupted behind, the lower end prolonged slightly beyond the upper. Within the space included between these ends is the external opening of the vagina (pl. 16, figs. 13, 14) and close behind it is the opening of the duct of the nidamental-albumen gland complex which is also the distal oviduct (pl. 16, fig. 13). The slender *vagina* passes obliquely downward and inward and receives two ducts, the one the duct of the *spermatocyst* (pl. 16, fig. 13) or first seminal receptacle, a nearly spherical or slightly pyriform thin-walled sac, about 1.8 mm. long by 1.1 mm. in diameter, lying upon the inner, ventral surface of the anterior genital complex. Its duct is about 1.5 mm. long and joins the vagina at the point where the duct of the *spermatheca* (the second seminal receptacle) joins with it at nearly a right angle. The other (pl. 16, fig. 13, *sph.*) is a large somewhat spherical, thin-walled vesicle, approximately 2.0 mm. in diameter, lying upon the postero-ventral face of the complex, its distal end and its duct in close contact with and partially inclosed by the prostate gland. Its duct is short and wide, 0.9 mm. long to its junction with the duct of the spermatocyst. No connection is to be found between the vagina and its two seminal receptacles and the oviduct, other than at the external opening.

The short *oviduct*, arising by the bifurcation of the distal hermaphroditic duct into the vas deferens and the oviduct, passes at once into the nidamental-albumen gland, opening into its wide duct which receives the secretions of the glands that produce the envelopes of the ova and the egg band. In copulation the spermatozoa are evidently deposited in the spermatheca, and pass from thence into the spermatocyst, thence outward to find their way from the vaginal opening into the external opening of the oviduct-nidamental gland complex within which fertilization of the ova and the formation of the egg band takes place. Lack of living material and other difficulties prevented a satisfactory working out of these details, in itself a very difficult undertaking.

## Subfamily PLEUROBRANCHAEINAE

Genus *Pleurobranchaea* LEUE

*Pleurobranchaea* LEUE, 1813. De *Pleurobranchaea* novo Molluscorum Genere. Dissert. Inaug. Acad. Halle, 13 pp., 1 pl. Genotype, *Pleurobranchaea meckelii* Leue.

*Pleurobranchaea californica* MacFarland, new species

Plate 15, figures 16-28; plate 17, figures 1-17

*Body* oval, elongate, convex, not at all depressed, the soft uneven mantle not covering the whole of the foot, distinctly separate from it laterally, sloping backward to merge with it behind, in front continuous with the head region and the frontal veil. Frontal veil broad, formed by the fusion of the two buccal tentacles, prolonged laterally as triangular, tapering, blunt, auriculate processes, the anterior margin bearing short, low, soft tubercles.

*Rhinophores* large, auriform, widely separated, directed nearly horizontally outward, canaliculate upon the posterior surface.

*Dorsum* light brown, mottled irregularly with darker brown and small whitish patches. Gill plume yellowish pink to light brown, its rachis and the edges of its laminae sprinkled with minute whitish flecks.

*Foot* broad, thick and muscular, rounded and bilabiate in front, bluntly pointed behind, with a large, median, ventral gland area in front of the tip; the sole pale yellowish, its anterior edge with a narrow marginal stripe of brown. Dorsal surface of tail with irregular, low papillae near its tip but no conspicuous median papilla evident.

*Gill plume* on the right side, large, bipinnate, not concealed by the mantle, attached to the body wall for over one-half of its length, and projecting freely behind. Rachis of gill smooth, bearing 50-55 triangular laminae above and below, each attached at its narrow base and bearing a great number of thin, closely set parallel lamellae upon its anterior and posterior surfaces.

*Anus* above the gill, about two-thirds of the length of its attachment from the anterior end; the renal pore inconspicuous, close below the gill attachment, about one-third of its length from the anterior end.

External pore of the prebranchial sac borne upon a prominent, finger-like, cylindrical papilla close in front of the anterior end of the gill, its opening cleft behind.

Female *reproductive openings*, when not everted, close together within a common shallow atrium midway in front of the gill and behind the right rhinophore. Male opening close in front of the female atrium, when in part everted it is borne at the summit of a large, inflated papilla curved slightly backward.

*Dimensions.* The specimens taken ranged from 35 mm. to nearly 210 mm. in length. The largest preserved specimen in a fairly flaccid condition measured 180 mm.

in total length, 100 mm. in width, and 60 mm. in height, the length of the foot 140 mm., its greatest width 85 mm. The width of the head from tip to tip of the velar processes was 85 mm., the distance between the bases of the rhinophores was 30 mm., their height 22 mm., and their basal diameter 9 mm. The gill was 50 mm. long, its attachment to the body wall was 20 mm. The right mantle margin overlapped the gill by some 20 mm., the left margin not conspicuous, the interspace between the posterior ends of the mantle margins 27 mm., smooth.

The large specimens of this species are much larger than those of any other so far recorded; *Pl. obesa* Verrill apparently is next with a length of 128 mm. in the preserved state.

The largest collection was dredged by the U. S. Fish Commission Steamer *Albatross* outside the Golden Gate and southeast of the Farallon Light, Station D-5789, 46 fathoms, fine green sand; October 21, 1912. Many very large and five small (35 mm. long) specimens were taken. The species has also been taken off Monterey on set lines.

The name "*Pleurobranchaea californica*" appears in several important papers by Dr. A. J. Carlson (1902, 1903, 1904) and by Jenkins and Carlson (1903). It was supplied from my manuscript at the time and is, of course, a *nomen nudum* as there used, being unaccompanied by an indication or definition or description by which it might be recognized taxonomically.

#### EXTENDED ANATOMICAL DESCRIPTION.

*Alimentary system.* Pharyngeal bulb frequently more or less protruded in preserved specimens through the eversion of the very extensible mouth tube, but not in normal living specimens. The bulb is large, conical, approximating one-third of the body length, measuring 55 mm. in length, 32 mm. in maximum width, and 25.5 mm. in height in a specimen of 165 mm. overall length. At the posterior end of the bulb the radula sac projects as a median, nearly spherical prominence.

*Mandibles.* Elongate paired chitinous plates in the lateral walls of the pharyngeal bulb. In a specimen of 165 mm. total body length they measured 34 mm. in length, and 16 mm. in width at the hinder end, narrowing to 6.5 mm. in width at the anterior end. Dorsal and ventral margins slightly convex, the posterior broader end is rounded, the inner face slightly concave, the anterior exposed functioning zone of about 2 mm. length, dark brown, more or less worn and jagged through use. The remainder of the mandible is inclosed in a deep, pocket-like sulcus in the lateral wall of the pharyngeal cavity. Near the bottom of this epithelium-lined sulcus the hinder end of the mandible curves outward and terminates, becoming progressively thinner as the end is approached. (Pl. 17, fig. 8.) In surface view the mandible plate presents a close mosaic of small polygonal areas of variable form, frequently slightly irregular, somewhat elongate hexagons. (Pl. 17, fig. 15.) Each of these is the free surface of a prism of similar form and of a length varying from very thin plates recently developed as cuticular thickenings upon the formative cells beneath the posterior end of the young mandible, to elon-



gate rodlets, attaining a height of 0.9 mm. at the anterior end. These top plates of the rodlets are slightly oblique to the long axis of the prisms, the expanded anterior margin being slightly higher than the posterior one, thus its serrate margin overlaps somewhat the preceding one. (Pl. 17, fig. 16.)

Each anterior margin bears from two to ten small, short, irregular denticles (pl. 17, fig. 17) directed forward and outward. These denticles are more regular in form and arrangement near the mid-axis of the plate, becoming more irregular as its dorsal and ventral margins are approached.

Longitudinal celloidin sections of the mandible *in situ* disclose all stages of the development of these rodlets in passing from the bottom of the sulcus toward the anterior end. Plate 17, figure 8 represents such a section under low magnification and (figs. 9-14) show typical areas in detail.

The inner surface of the invaginated mucous membrane of the mouth is lined by a single layer of cuboidal or low columnar epithelium resting upon a homogeneous basement membrane, with a distinct cuticle upon the free surface which shows lenticular thickenings opposite the distal ends of the mandible rodlets formed upon the cells of the opposite wall.

At the bottom of the sulcus, this epithelium doubles back upon itself and is transformed into the formative cells, rhabdoblasts, and rodlets, the cells increasing in size and taking on a high columnar form. The first sign of the formation of the top plate of the future rodlets is the appearance of an arched group of minute, pointed denticles (*b*) around the anterior margin of each rhabdoblast, accompanied by the formation of a delicate layer of chitin (*c*), covering the free surface of the cell and uniting the denticles, the forerunner of the top plate of the rodlet. (Pl. 17, figs. 10, 11.) Opposite the middle of each top plate, the slight lenticular thickenings of the outer cells of the cuticle are formed, each fitting into the slight depression in the outer surface of the opposed rodlets. (Pl. 17, fig. 12, at *x*.) Laterally these disks are continued by a delicate membrane-like cuticle uniting them in a continuous layer.

These thickenings do not become a part of the rodlets, nor does the membrane of which they form a part thicken appreciably until the margin of the sulcus is approached. Here they are reinforced by additional layers of chitin and the cuticle thus formed is doubled back to unite with the much thicker general cuticle of the mouth cavity. (Pl. 17, figs. 8, 9.)

Each rodlet develops upon the upper surface of a large cuboidal rhabdoblast (fig. 13, *e*). With the appearance of the denticles and their union into the first layer of the top plate, the cuticle progressively extends inward, covering the distal ends of the rhabdoblasts as a sort of cap, the distal ends of the cells becoming slightly separated from each other in a sort of dome-like form which is inclosed by the down-growing wall of the rodlet, thus separating its sides from contact with the adjacent cells save in a narrow basal zone. (Pl. 17, fig. 10, *f*.)

The rhabdoblast nucleus is fairly large, showing a large nucleolus and small chromatin granules; the cytoplasm is slightly granular. As successive layers of the rod-



lets are formed, the top plate is progressively elevated, the layers of cuticular substance being marked off by curved lines, in general parallel with the distal surface of the cell, first appearing below the denticle ridge and then arching across the full diameter of the rodlet. These appear to be actual septa in early stages, but later they seem to resolve themselves into thickened lines within the peripheral wall of each prism.

The rodlet appears to be hollow, or at least filled with some transparent substance, not giving the usual reactions of chitin which are characteristic of its wall.

As the rodlets approach their full development, their formative cells become less dome-shaped, and with the completion of the rodlet the rhabdoblats flatten, assume a more cuboidal form, and divide rapidly into slender, columnar cells which at once take up the formation of a homogeneous basal cuticula upon which the rodlets are implanted. (Pl. 17, fig. 14, *d.*) This increases rapidly, at the anterior boundary the rodlets cease, and the basal cuticula continues.

The fixation of the material, unfortunately, gives no trustworthy evidence of the type of cell division involved.

*Radula* (pl. 15, figs. 16-28) long and broad, reflected outward at its anterior end, deeply grooved in the median line behind and becoming almost tubular in the radula sac. The teeth are borne in from 36 to 52 rows, the anterior ones worn and broken through use. For a large adult specimen the radula formula reached 52 (130-145.1.145-130), in a young one of 35 mm. length it was 36 (70.1.70). Two radulae were used from animals 36 mm. and 165 mm. in length.

The narrow *rachis* bears a single, small, median tooth, not always to be found. It has a narrow, somewhat triangular form (pl. 15, figs. 16, 17, 19) and bears a single pointed, somewhat elevated cusp upon a narrow base. In a large specimen the median teeth measured 0.042 mm. in length, and 0.021 mm. in width, these measurements being quite constant in all the rows where found. It is well separated from the first lateral tooth of either side and shows no trace of an accessory cusp or denticle.

*Laterals.* The lateral teeth are of similar form throughout the row, the innermost or first lateral measuring 0.255 mm. in length, the succeeding ones increasing progressively in length to about 0.87 mm. or 0.90 mm. in the 20th tooth, thence decreasing gradually to about 0.30 mm. in the outermost (140th) one. In a typical lateral from the inner half of the row, the base (pl. 15, figs. 22, 24) is much compressed and elongated, and is implanted (pl. 15, fig. 16) in the general basal cuticula at an angle of approximately 45° to the direction of the row. The anterior portion of the base is somewhat triangular (pl. 15, fig. 17); its posterior part is narrowed abruptly and terminates in a hollowed, rounded, or hook-like facet with thickened margins and concave center. The body of the tooth rises obliquely from this base at a small angle and is prolonged into a strong, pointed cusp, curving outward at its tip.

The dorsal surface of the tooth is convex, the cusp in a cross section near its tip is a flattened ellipse, further toward the base its lateral edges become squarish and then concave instead of convex. Upon the ventral inner edge of the concave inner surface,

about midway of its length, is borne a short, small denticle (pl. 15, figs. 22-27) below which the margin continues as a wing-like expansion to the tip of the base, the dorsal edge dying away in the surface.

Upon the outer face of the tooth the concavity increases in depth toward the base, its upper thin edge widens out into a thin wing-like expansion, the surface of which makes a sharp line of union with the dorsal surface, the whole wing thus formed overlapping the inner portion of the next adjacent tooth. (Pl. 15, fig. 24.) The lower edge of the outer face is continued downward into the dorsal surface of the rounded facet at the hinder end of the base of the tooth. (Pl. 15, fig. 23.)

Toward the outer end of each half-row the laterals become more compressed and slender, their bases narrower and less oblique to the axis of the row. The lateral denticle on the inner face is absent on the first lateral, but present in the succeeding ones in about uniform size, becoming rudimentary and disappearing in about the hundredth tooth of the row. The outermost laterals become very slender and compressed.

Malformations of the lateral teeth occur in some specimens. A notable case was found in which the third to seventh laterals on one side were more or less fused together throughout the whole length of the radula, all other teeth being normal.

In comparison with those of other described species, the denticles borne upon the inner surfaces of the lateral teeth are very small, while in some species they are so large as to nearly justify the name of accessory cusps.

In a young specimen (pl. 15, fig. 23) measurements are as follows:

Length of lateral, tip of base to tip of cusp, .270 mm.

Length of base .144 mm.

Length of denticle .039 mm.

Length of cusp .132 mm.

Bergh (1897) was unable to find a median tooth in the radula of *Pl. meckelii*, or any other species of *Pleurobranchaca* that he examined. Vayssière (1901) figured a small median tooth in *Pl. brockii* Bergh, five examples only of it having been found in the specimen he studied, the others having been detached and lost. He saw a median tooth also in *Pl. meckelii* in several instances, but such seem to be easily detached and lost, and are to be found in the inrolled hinder portion only of the radula.

The median tooth is trapezoidal in form, divided lengthwise by a faint median furrow into two symmetrical halves, each of which bears a minute denticle at the angle next to the posterior end of the median furrow, and another at the outer margin of the tooth. Such a tooth is interpreted by Vayssière as being formed by the fusion of the first lateral teeth of either side, the denticles representing the cusp and the inner lateral denticle of each.

*Reproductive system.* (Pl. 17, figs. 1-7.) The large ovotestis covers the right superior lateral and posterior surfaces of the liver. The hermaphroditic duct, formed by the union of numerous branches from the lobes of the gonad, is at first quite slender, long, and nearly transparent. It passes below the intestine and gradually dilates into the long, whitish, closely convoluted hermaphroditic ampulla. Reaching the surface of

the anterior genital complex, it narrows rapidly and divides into the *vas deferens* and the *oviduct*. (Pl. 17, fig. 7.)

The former at once passes through the lobulated prostate gland. This light yellow, flattened, spheroidal gland lies on the outer, anterior face of the anterior genital complex and is divided into deep lobes, the surface of each lobe showing the rounded tips of more or less radially arranged glandular tubules. These tubules join a number of ducts which open into the *vas deferens* as it passes through the gland. (Pl. 17, figs. 3, 4.) From a deep depression in its anterior face the *vas deferens* emerges and courses outward and upward to the lower outer surface of the penis sheath which it penetrates. (Pl. 17, figs. 1, 2, 5.)

The *penis* (pl. 17, fig. 5) is situated transversely upon the upper anterior face of the anterior genital complex, joining the genital vestibule distally, its base attached by the flattened band-like retractor penis muscle (pl. 17, fig. 1) to the left dorsal wall of the body. It is inclosed within the thin-walled, flattened-cylindrical penis sheath which extends from its distal insertion in the integument surrounding the external male opening inward to the retractor penis muscle, enveloping it as a conical prolongation and soon fusing with its epimysium.

The *penis*, consisting of the preputium and the inclosed glans penis, occupies nearly the full length of the external sheath. Its appearance varies somewhat in specimens showing the completely retracted condition (pl. 17, fig. 5) as compared with others in which it is more or less completely everted (pl. 17, figs. 1, 2).

The *vas deferens* penetrates the outer sheath and describes a number of loops within it and enters the expanded base of the penis, opening into the central canal of the glans. (Pl. 17, fig. 1.) It is lined by a clearly defined, though thin, translucent cuticle. It shows no appreciable change in diameter throughout its course within the penis sheath, contrary to what is described by Bergh (1897, pp. 25-26) for *Pl. meckelii*.

According to him, the duct changes abruptly in diameter inside the sheath and is divisible into a thicker and a thinner segment. Then, too, the duct is described as entering the sheath, passing to its proximal end, emerging through its wall, coursing along the *M. retractor* for one-half its length, passing transversely through a hole in the muscle and returning to the penis sheath, which it again penetrates, increasing in thickness and becoming long and spirally convoluted before entering the base of the penis proper.

In the present species the *vas deferens* does not emerge from the penis sheath after once entering it.

The base of the penis is wide and somewhat hemispherical. (Pl. 17, fig. 1.) Upon its proximal end surface is inserted the retractor penis muscle. Its distal portion is prolonged into the hollow tubular preputium which is relatively thick walled and muscular. Distally it merges with the wall of the genital cloaca into which its cavity opens through the male aperture. (Pl. 17, figs. 1, 2.)

Inclosed within the preputium is the long, tapering, whip-like, muscular glans penis. In an adult specimen (pl. 17, fig. 1) its thick basal portion, 0.5 mm. in diameter, was folded back upon itself for about 2.5 mm., then rapidly tapered to a diameter

of 0.08 mm. near the coiled tip. In a small, immature specimen (pl. 17, fig. 5), the preputium and inclosed glans are nearly straight, the preputium opening into the common genital cloaca close in front of the common female opening of the vagina and the accessory glands.

In a large specimen with nearly everted glans (pl. 17, fig. 2), the arrangement at first sight seems quite different. The male opening is here upon a broadly conical process of the integument, from which the slender elastic glans protrudes.

The distal end of the preputium is dilated somewhat, the basal end of the penis now occupies the distal end of the outer sheath inclosing the loops of the vas deferens. The large external papilla, possibly in part a fixation artifact, is formed by a part of the genital cloaca, together with a part of the adjacent body wall. The distal end of the outer sheath is attached to the basal part of the papilla, but the exact extent of its cavity is not clear owing to the transparency of its wall. Its fibers radiate outward and unite with the inner surface of the papilla. This outer sheath evidently incloses a vascular sinus surrounding the penis and vas deferens.

Bergh (1897, pp. 25-27) describes the glans penis of *Pl. meckelii* as differing from this in being very short, papilla-like at the base of the preputium; here it is very long and slender, whip-like. Bergh described the rather thick, glassy inner lining of the vas deferens which extends from the region near the second entrance of the deferent duct into the outer sheath to a point near its termination at the apex of the glans. A flattened infolding of this cuticle is described as extending into the lumen.

Mazzarelli (1891, pp. 233-243) indicated the presence of a slender elastic filament of a keratin-like substance within the lumen of the vas deferens. In pairing, the tip of the glans extends into the oviduct toward the spermatheca, while the filament is pushed inward along the oviduct as far as the caeca of that organ, and is the last to be withdrawn when the animals are forcibly separated.

*Oviduct.* (Pl. 17, figs. 5, 6, 7.) Immediately following its origin by the bifurcation of the hermaphroditic duct, the oviduct dilates into a thick-walled segment closely attached to the posterior face of the prostate gland. This segment forms a number of close loops with saccular enlargements along their greater curvatures, and measures approximately 15 mm. in length in a large specimen.

The oviduct then narrows abruptly and passes across the upper surface of the large, thin-walled, spherical spermatheca for about 16 mm., and dilates into a reniform enlargement on one side just before it opens into the spermatheca. The lumen of the duct lies at one side of this dilation and its thickened wall is thrown into a number of irregular diverticula. (Pl. 17, fig. 6.) This enlargement may serve as a spermatocyst.

Close to the entrance of the oviduct into the spermatheca it emerges again as the vaginal duct, dilating and passing directly outward as the vagina to its external opening in the side of the short and broad duct of the accessory glands. This complex is relatively small, somewhat flattened-ovoidal in form, its proximal end capped by the finely lobulated albumen-gland portion, resting upon the larger, more coarsely lobulated mucous division. (Pl. 17, figs. 5-7.)

The central nervous system of *Pl. californica* does not depart sufficiently from that described by Bergh and by Vayssière for *Pl. meckelii* to justify detailed description here. The same may be said of the heart and pericardium, the kidney, and the pre-branchial sac.

## Suborder NUDIBRANCHIATA

### Superfamily DORIDACEA

#### Family POLYCERIDAE

#### Subfamily NOTODORIDINAE

#### Genus *Aegires* LOVÉN

*Aegires* LOVÉN. 1844. Öfvers. Vetensk Akad. Forh., vol. 1, p. 49. Type *Aegires punctilucens* d'Orbigny, 1837. Index Moll. Scand., p. 6. ALDER and HANCOCK. 1848. Monog. Brit. Nudibr., pt. 4, fam. 1, pt. 21; 1854, pt. 5, fam. 1, pl. 17, figs. 13-15; genus 4, 1855, pt. 7, p. 44, appendix, pt. 19.

#### *Aegires albopunctatus* MacFarland

Plate 18, figures 5-8; plate 31, figures 1-5

*Aegires albopunctatus* MACFARLAND. 1905. Proc. Biol. Soc. Washington, vol. 18, p. 45. MACFARLAND. 1906. Opisthobr. Moll. Monterey Bay. Bull. U.S. Bureau of Fisheries, Washington, vol. 25, p. 133, pl. 19, figs. 41-44. O'DONOGHUE. 1927. Notes, Nudibranchiate Mollusca, Vancouver Island Region. V. Trans. Roy. Can. Inst., Toronto, vol. 16, pt. 1, pp. 7-9, pl. 1, figs. 7-9.

*Body* arched, limaciform, not at all depressed, robust and firm to the touch owing to abundant spicules of the integument. Highest and broadest immediately in front of the branchial plumes, from which it slopes rapidly downward behind into the broad bluntly pointed tail, in front more gradually to the head.

*Dorsum* rounded, thickly set everywhere with short blunt tubercles, cylindrical or with slightly expanded apices, arranged in irregular longitudinal rows, which, in some specimens, are borne on incomplete low ridges, more conspicuous in specimens somewhat shrunken in preservation, but entirely absent in more distended ones.

A clearly defined dorso-lateral line of tubercles begins at the posterior end of the frontal margin and continues backward as a tuberculate ridge becoming less and less prominent until finally, as a row of tubercles, it curves upward behind the branchial plumes to meet its fellow of the opposite side.

Much less clearly defined rows of larger and smaller tubercles may be traced upon the notum in some specimens, but in others their identity is lost among the irregu-

larly distributed intermediate tubercles. Frontal margin tuberculate with one or two rows of tubercles behind which the dorsal surface of the head is likewise tuberculate. Posteriorly, the sides below the dorso-lateral margin with but a few scattered small tubercles, becoming more numerous and larger toward the end of the body behind the branchiae, where they form three fairly distinct rows.

*Foot* narrow, linear, its sides narrow, undulating, rather thin, clearly set off from the sides of the body, the anterior end truncate, undivided, the angles simply rounded, behind tapering abruptly into the short, rounded tail.

*Mouth* small, inconspicuous, with a small lobe-like tentacle on each side.

*Rhinophores* simple, cylindrical, truncate, perfectly smooth, completely retractile within prominent tuberculate sheaths bearing five or six, high, rounded tubercles, higher on the outer than the inner side.

*Branchial plumes* three, tripinnate, small, postero-dorsal, the lateral ones protected by a large irregularly tuberculate lobe upon the outer side, the single median plume with a similar branching lobe immediately in front of it in the median line. Anal papilla low, close behind the branchiae.

*Ground color* white or pale yellowish white, with irregularly scattered, small, dark-brown or even black spots, or entirely white. Dorsum everywhere between the tubercles and sides sprinkled with minute dots of pure white. Club of rhinophore lemon yellow with minute spots of white. Gill plume without any brown or black pigment save occasional scattered spots. Foot white.

The *tubercles* of the dorsum are cylindrical with flattened or slightly rounded summits. They, and the general integument, are strengthened by very numerous small spicules having the form of double-pointed, slightly curved rods. To their presence is due the hard, resistant feel of the animal.

*Pharyngeal bulb* short, strong, nearly spherical in shape, about 2 mm. in length, slightly less in height and width, the radula sac projecting behind and below for 0.5 mm. Labial disk convex, the mouth opening triangular, clothed with rather thick cuticula. Roof of the mouth opening occupied by a single, broad, thick mandibular plate, in front of it a narrow girdle of fine, rod-like, cuticular thickenings guarding the opening. This mandibular plate is quadrangular, its anterior edge straight and very thick, the posterior one much thinner and rounded at the corners. Width of mandible 0.345 mm.

*Radula* broad, deeply grooved, colorless, except in the posterior rows which are yellowish. Teeth in 16-22 rows, the last two immature, the formula of the dentition 16-



22(17·0·17). Rachis narrow, naked, pleurae 17, similar in form, strongly hamate, the innermost the smallest, the succeeding four increasing in size, the remaining ones nearly equal, the outermost one slightly smaller. (Pl. 31, figs. 1-3.)

*Spermatotheca* spherical, spermatocyst pear-shaped, small. Glans penis cylindrical, short, bluntly rounded at tip, its canal clothed with very minute, densely set hooks.

*Dimensions.* Largest specimen recorded taken by dredging in Monterey Bay in 1899. Total length 21 mm., width 7 mm., height 7 mm.; foot length 18 mm., width 3 mm. Average specimens range from 13 mm. long  $\times$  3.5 mm. wide  $\times$  4 mm. high to smaller ones of proportional dimensions.

*Habitat.* Under overhanging rocks and in tide pools upon algae at low tide. Vancouver Island region to San Diego. Not rare along the coast from Monterey to Point Lobos.

This species has been recorded by O'Donoghue (1927) as having been dredged by him in 1-12 fathoms in Departure Bay, Vancouver region. It is also recorded for San Pedro, California, by Cockerell and Eliot (1905), and for Laguna by Guernsey (1912), and by O'Donoghue (1927). Abundant at Newport Bay and La Jolla in April-June, 1946.

*Aegires albopunctatus* is very sluggish in movement, shuns the light, and can be kept for but a few days in the aquarium. Its egg band is white, short, and narrow, and forms a spiral of one to two turns. It has been deposited in the aquarium occasionally.

#### Subfamily POLYCERINAE

##### Genus *Laila*\* MACFARLAND

*Laila* MACFARLAND, 1905. Proc. Biol. Soc. Washington, vol. 18, p. 46. MACFARLAND, 1906. Bull. U.S. Bureau of Fisheries, vol. 25, p. 134.

*Body* depressed, frontal and lateral margins narrow, set with club-shaped papillae, rhinophores perfoliate, retractile into low sheaths; branchial plumes few, tripinnate, non-retractile into sheath, tentacles blunt, canaliculate. A flattened subpallial ridge on each side of the anterior end of the body just behind and above the tentacles.

No labial armature nor mandibles. Radula not narrow, the rachis with a single series of flattened, rudimentary teeth: first lateral tooth slender, hook-like, the second large, the remaining laterals smaller, broad and flattened. Glans penis armed with hooks.

\*Name from Nizami's Persian poem "Laila and Majnun." Nizami was a Persian poet of the 12th century. Translation, 1883.

**Laila cockerelli** MacFarland

Plate 20, figure 4; plate 29, figure I; plate 31, figures 6-12

- Laila cockerelli* MACFARLAND, 1905. Proc. Biol. Soc. Washington, vol. 18, p. 47. MACFARLAND, 1906. Bull. U.S. Bureau of Fisheries, vol. 25, pp. 134-135, pl. 19, figs. 45-50; pl. 27, fig. 15. GUERNSEY, 1912. First Annual Report Laguna Marine Laboratory, p. 77, fig. 39 A. GUERNSEY, 1913. Journ. Entomol. and Zool., Pomona College, vol. 5, no. 2, pp. 88-92, figs. 1-2. GUERNSEY, 1913. The Anatomy of *Laila cockerelli*. Journ. Entomol. and Zool., Pomona College, vol. 5, no. 3, pp. 137-157, figs. 1-5. O'DONOGHUE, 1921. Nudibr. Moll., Vancouver Island Region. Trans. Roy. Can. Inst., Toronto, vol. 13, pt. 1, pp. 163-165, pl. 2, figs. 15-17. O'DONOGHUE, 1922. Trans. Roy. Can. Inst., Toronto, vol. 14, pt. 1, p. 164. O'DONOGHUE and O'DONOGHUE, 1922. Trans. Roy. Can. Inst., Toronto, vol. 14, pt. 1, pp. 138-139, pl. 4, fig. 8. O'DONOGHUE, 1927. Journ. Entomol. and Zool., Pomona College, vol. 19, pp. 99-100, pl. 2, figs. 54-56. JOHNSON and SNOOK, 1927. Seashore Animals of the Pacific Coast, New York, pp. 494-495, pl. 9, fig. 3.

*Body* (pl. 20, fig. 4) elongate, depressed, the ends rounded, the dorsum slightly convex, the mantle margin prominent, overlapping the foot everywhere except behind. Pallial margin all around bearing numerous stout club-shaped papillae arranged in short oblique rows of three or four papillae each, increasing progressively in size from the outer ones inward. Length of papillae 1-6 mm., breadth up to 1 mm. Each papilla is supported by an axial column of strong spicules; median portion of dorsum with numerous, scattered, low tubercles of varying size, the largest near the median line, otherwise rather smooth. In some specimens these larger tubercles tend to be arranged in a somewhat irregular series down the mid-dorsum from in front of the branchial plumes to the frontal margin; in others this is not so apparent. In preserved material the large papillae of the pallial margin may become quite inflated in their distal portions, the proximal part appearing as if strongly contracted. The integument of the dorsum is reinforced by a network of spicules which show clearly as interlacing lines.

*Head* wide, sloping above, the frontal margin prominent, the mouth opening large with conspicuous, fleshy, plicated lips. Along the sides of the head and anterior end of the body on each side is borne a longitudinal, fleshy, flap-like subpallial ridge, its anterior end just behind and slightly above the base of the oral tentacles, close below the pallial margin and parallel to it, and above the anterior end of the foot. The anterior and posterior ends of the ridge are rounded, the margin smooth. Length of ridge 2 mm., its width 0.5 mm., in a large specimen. (Pl. 31, fig. 6.)

*Foot* linear, abruptly pointed behind, and extending beyond the mantle, its margins thin and broad, in front squarish, slightly emarginate, the corners rounded, deeply bilabiate, the upper lip projecting beyond the lower and slightly concave.

*Tentacles* cylindrical, truncate, grooved on the upper surface throughout the entire length. Length of tentacles about 2 mm., diameter at the base 0.7 mm., at the apex 0.3 mm.

*Rhinophores* retractile within smooth-margined sheaths. Stalk and clavus of nearly equal length, the latter slightly dilated, perfoliate with about 13 leaves, and tapering above to a blunted apex. (Pl. 29, fig. 1.)

*Branchial plumes* five, non-retractile into a branchial pocket, tripinnate, arranged in an incomplete circle, the center of which is occupied by the low anal papilla. Renal opening at the right of anal papilla and near its base.

General *body color* slightly translucent pale yellow, or entirely white. Clavus of rhinophores, processes of pallial margin, and tail tipped with deep red-orange, the branchial plumes and dorsal tubercles occasionally flecked with the same color. Dorsum marked with an irregular network of transparent lines upon the white background, the effect of multitudinous spicules shining through the integument.

*Pharyngeal bulb* small, flattened, oval in shape, the radula sheath projecting slightly behind. Lip disk directed obliquely downward, strongly convex, covered by a thin colorless cuticula, the mouth opening vertical, slit-like, with a slight transverse widening at dorsal and ventral ends formed by shallow grooves at either side. Cuticle somewhat thickened at the mouth opening, behind it showing a faintly tessellated appearance but with no distinct armature present.

*Radula* nearly colorless, broad, with wide median groove. Radula formula 76-82 (10-13·2·1·2·10-13). Teeth in 76-82 rows, the last two or three incompletely developed. Rachis narrow, with a single series of thin, colorless, flattened plates or rudimentary teeth, nearly rectangular in form, slightly broader at the anterior than at the posterior end, the edges irregular. Average length 0.018 mm., width of anterior end 0.011 mm., of posterior end 0.008 mm. (Pl. 31, figs. 7-10.) Pleural teeth two, the innermost one a simple, strongly curved hook directed vertically, its shaft somewhat expanded at its posterior end and fitting closely to the second pleural tooth. Length 0.036 mm. Second pleural tooth strong, heavy, the shaft irregular in form, oblique: at its upper end two strong, hooked cusps, the inner smaller and directed inward, the larger, outer one vertical, the two together forming a crescentic figure as seen from above. Below the inner hook a rounded elevation on the upper inner margin of the shaft, continuing obliquely outward into a ridge. Lower end of shaft bluntly rounded bearing a slight, wing-like elevation on its outer face. Length of typical second pleural tooth from end of shaft to crest 0.038 mm., diameter below inner cusp 0.011 mm.

Outer lateral teeth, the uncini, 10 to 13 in number, closely set, pavement-like, presenting an arched quadrangular outline with two pointed cusps at the lower angles, strongly developed in the first four uncini, but becoming obliterated in the outer ones, which become reduced to rather thick, flattened plates.

*Reproductive opening* on the right side. Everted penis at the center of a ridge-like spiral fold. Glans penis long, cylindrical, blunt, about  $40\mu$  (0.040 mm.) long by  $42\mu$  (0.042 mm.) in diameter with armature of minute thorn-like hooks, about  $14\mu$  (0.014 mm.) arranged in 10 to 12 slightly irregular longitudinal rows.

*Dimensions*, living specimens. Total length of the largest specimen taken 20 mm., width 7 mm., height 6 mm. Another, length 18 mm., width 5 mm., height 3 mm.; dorsal processes 1-6 mm. in length, 1 mm. at widest point.

*Habitat*. Under shelving rocks in tide pools along the coast of the southern shore of Monterey Bay and adjacent coast. Not rare. The species has also been recorded by O'Donoghue (1921) from the Vancouver Island region, by Cockerell (1905) from San Pedro, by Guernsey (1912) and by O'Donoghue (1927) from Laguna, and by Johnson (1927) from San Diego. Two specimens are reported taken at Deadman Island, San Pedro Bay, 1897. So far but one species of this interesting genus has been described.

### Genus *Triopha* BERGH

*Triopha* BERGH. 1880. On the Nudibranchiate Gasteropod Mollusca of the North Pacific Ocean. (Dall, Explor. of Alaska, I, Art. 6), II, pp. 261-266; (also in Proc. Acad. Nat. Sci. Phila., 1880, vol. 32, p. 112). Type *Triopha modesta* Bergh. BERGH. 1892. System der Nudibr. Gasteropoden, p. 148. BERGH. 1894. Die Opisthobranchien. Bulletin Museum Comp. Zool. Harvard, vol. 25, no. 10, pp. 184-187. MACFARLAND, 1905. Prelim. Account of Dorididae of Monterey Bay, California. Proc. Biol. Soc. Washington, vol. 18, p. 48. MACFARLAND. 1906. Opisthobranchiate Mollusca from Monterey Bay, California, and Vicinity. Bull. U.S. Bureau of Fisheries, Washington, vol. 25, p. 135.

### *Triopha carpenteri* (Stearns)

Plate 19, figures 3, 4; plate 29, figures 4-6; plate 31, figures 13-18

*Triopha carpenteri* STEARNS. 1873. Description of a New Genus and two New Species of Nudibranchiate Mollusks from the Coast of California. Proc. Calif. Acad. Sci., vol. 5, p. 78, fig. 2. Generic name *Triopha* from Johnston, Annals and Mag. of Nat. Hist., 1838, vol. 1, p. 123.

*Triopha carpenteri* (Stearns). MACFARLAND. 1905. Proc. Biol. Soc. Washington, vol. 18, pp. 48-49. MACFARLAND. 1906. Bull. U.S. Bureau of Fisheries, Washington, vol. 25, pp. 135-137, pl. 19, figs. 51-55; pl. 21, figs. 108, 113; pl. 27, figs. 16, 17. JOHNSON and SNOOK. 1927. Seashore Animals of the Pacific Coast, p. 495, pl. 10, fig. 1. O'DONOGHUE. 1927. Journ. Entomol. and Zool., Pomona College, vol. 19, pp. 96-97, pl. 2, figs. 45-47.

*Body* limaciform, elongate, robust, anteriorly obtusely rounded, posteriorly rather bluntly pointed.

*Head* obliquely flattened, semi-lunar, bearing a narrow frontal margin extending laterally beyond the rhinophores. This margin is continued behind into the less conspicuous dorso-lateral ridge; bearing along its entire length a large number of irregularly lobed and tuberculate papillae, eight to ten of which are borne on the frontal margin. Dorsum slightly arched, set off from the sides by a series of tuberculate processes, five to nine in number, of varying size and form, borne upon an inconspicuous low ridge, in many cases almost indistinguishable. The first of these processes lies upon the continuation of the velar margin behind the rhinophore region, the last two or three are behind the branchiae.

Scattered upon the minutely granuliferous dorsum are many simple or compound tubercles, in some cases approximating the size and complexity of the marginal series. These are usually irregularly distributed, tending, however, in many specimens to form a median series of four or five along the anterior dorsum, and continuing, as if forked, to the branchiae giving an inverted-Y pattern. Behind the branchiae a median tubercle, and often several scattered ones, and in front of the rhinophores two or three similar ones.

*Rhinophores* retractile within prominent sheaths, the margins of which are thin, smooth, or slightly wavy in outline. Stalk stout, erect, the clavus curved backward and upward, perfoliate with 20-30 leaves.

*Branchiae* five, large, wide-spreading, tripinnate, entirely separate, arranged at the points of a hexagonal figure surrounding the prominent anal papilla, an anterior plume being placed in the median line, the other four in pairs lateral to that plane. Occasionally a sixth asymmetrical plume may be present, or the normal number of five may be reduced through injury. Close to the base of the anal papillae on its right side is the minute renal pore.

*Tentacles* short, stout, auriform, a longitudinal slit along their outer border.

Anterior margin of *foot* rounded, entire, the sides nearly parallel, the posterior end rather abruptly pointed.

General *body color* white, inclined to pale yellow above, often sprinkled with minute white flecks borne upon very small tubercles. Tips of branchiae, clavus of rhinophores, appendages of the frontal and lateral margins, the tip of the tail, and the numerous scattered tubercles of the dorsum a deep orange color. Numerous irregular blotches of orange are also scattered along the sides of the animal in no regular arrangement. The region of the body beneath the branchial plumes is darker, owing to the deep-brown liver showing through the skin. Considerable variation in the depth and amount of the orange color may be found in different specimens of varying ages and sizes. In alcoholic material the orange color disappears entirely.

*Mouth opening* a vertical slit, or somewhat like an inverted T, surrounded by full, plicated lips covered by a strong cuticula. Behind the oral slit the cuticula passes laterally into a triangular brownish-yellow plate, broad above, its apex directed downward, approximately one-third higher than long. These two mandibular plates are made up of closely set, slightly curved, slender, blunt rodlets, longest at the anterior border and decreasing in length behind and below.

*Radula* broad, deeply grooved, dark amber in color. Radula formula 33 (9-14:9-18:4-9-18-9-14). Teeth in 33 rows, the rachis broad with 4 rows of flattened plates (rudimentary or spurious teeth), the inner two rows quadrangular in form in the older portion of the radula, about 0.8 mm. wide by the same in length, grayish yellow, the anterior margin thickened and smooth, the lateral and posterior ones irregular.

In the younger portion of the radula these plates become lighter in color, trapezoidal in shape, and much wider than long. The outer row of rachidian plates on either side are more triangular in form, the slightly thickened, anterior margin being much narrower than the posterior ones, the outer posterior angle being prolonged backward and outward, especially in the posterior portion of the radula, when it becomes a long process extending underneath the adjacent, overlapping, pleural teeth.

Pleurae yellow, strongly hooked, of nearly uniform shape and size, the number varying in different specimens from 9 to 18. The base of each hook bears a vertical, wing-like process near its posterior end. Uncini 9 to 14, quadrilateral, a conspicuous longitudinal crest directed toward the median line in all except the outermost three or four.

*Blood gland* large, 2.5 mm. long, 4.5 mm. wide, 1 mm. thick, lobules placed transversely behind and in contact with the central nervous system. A posterior lobe behind and below the anterior.

*Prostate gland* long, thick, and lobulated, followed by a narrow muscular vas deferens which dilates into a sausage-shaped cylindrical ampulla, followed by the penis. Glans penis and distal portion of its duct armed with minute hooks.

*Dimensions.* Largest specimen preserved in alcohol: length 60 mm.; height, immediately in front of branchiae, 29 mm.; greatest width 15 mm.; width of head 15 mm.; maximum height of dorso-lateral processes, 3 mm.; length of foot, 57 mm.; its greatest breadth, 7 mm.

*Living specimen* length records range from 16 mm. to 84 mm. Many half-grown specimens are plentiful in midsummer.

*Habitat.* On brown kelp of the fucoid zone and under overhanging rocks in tide pools all along the coast of the Monterey Bay region. Very common and conspicuous. Recorded by O'Donoghue (1927) from Laguna, and by Johnson and Snook (1927) from San Diego. Taken by the writer at Crescent City, 1940, and at Newport Bay, Laguna, and La Jolla, 1946.

The description of this species by Stearns, though brief, is entirely adequate to insure the identification of the living animal. It is as follows:

"Animal slug-shaped; anteriorly obtusely rounded, posteriorly pointed, somewhat attenuated; cephalic tentacles clavate, upper part of same of an orange color, below white; gill plumes five, arborescent, resembling fern leaves, tipped with orange; plumes and tentacles 1-16 inch in length; the former situated in the middle of the back somewhat posterior to the centre. Six tentacular processes on each side, tipped with orange and 1-32 inch long; also short tentacular processes in front of the head; body one and one-half inches in length, translucent white, covered with fine papillae of an orange color.

"*Habitat:* Monterey, at Point Pinos, near the lighthouse, on the under side of granite rocks at edge of laminarian zone. . ."



Bergh's (1880) establishment of the genus *Triopha* was based upon the species *Triopha modesta* which he described in that publication, listing *Tr. carpenteri* (Stearns) as a doubtful synonym, though at the end of his generic diagnosis he listed *Tr. modesta* Bergh, n. sp., and *Tr. carpenteri* (Stearns) as the two species of his new genus. Since his generic characters are based entirely upon *Tr. modesta* which was the only one he had studied, it is evident that that species might have been considered as the genotype, and not *Tr. carpenteri* (Stearns), subsequently designated by O'Donoghue (1926, p. 214). In 1892, Bergh again listed them as distinct species on page 148, but two years later (Bergh, 1894) he placed *Tr. carpenteri* as a synonym of *Tr. modesta*. If the two are identical, the earlier name given by Stearns should replace that given by Bergh.

While no further studies seem to have been made upon *Tr. modesta*, Bergh's descriptions are in characteristic detail and it is evident from their comparison with those of the present writer (1905, 1906) that the two species are actually distinct, which view was accepted by O'Donoghue (1922, p. 136). The Alaskan species seems to have been dredged in depths ranging from 6 to 43 fathoms (two specimens only).

### *Triopha maculata* MacFarland

Plate 19, figures 5, 6; plate 31, figures 19-21

*Triopha maculata* MACFARLAND, 1905. Proc. Biol. Soc. Washington, vol. 18, p. 49. MACFARLAND, 1906. Bull. U.S. Bureau of Fisheries, Washington, vol. 25, pp. 137-139, pl. 19, figs. 55a-59; pl. 21, figs. 106, 107; pl. 28, fig. 18. O'DONOGHUE, 1926. Trans. Roy. Can. Inst., Toronto, vol. 15, pt. 2, pp. 214-215. O'DONOGHUE, 1927. Journ. Entomol. and Zool., Pomona College, vol. 19, pp. 98-99, pl. 2, figs. 51-53. JOHNSON and SNOOK, 1927. Seashore Animals of the Pacific Coast. New York, Macmillan Co., pp. 495-496, pl. 10, fig. 3.

*Body* limaciform, plump, strongly rounded above, the back passing almost imperceptibly into the sides save for the line of processes which indicates the dorso-lateral boundary. Sides slightly compressed, a shallow longitudinal groove immediately above the margin of the foot; foot linear, bluntly rounded in front, less so behind. Head flattened, sloping forward from the rhinophores to the broad semicircular frontal margin which bears a fringe of from 10 to 12 short, stout processes, each of which, toward its distal end, branches into several blunt or knob-like divisions, which may in turn be branched or knobbed. The frontal margin extends laterally below the level of the rhinophores. In its prolongation along the dorso-lateral area is a series of four to six short branched processes similar to those of the frontal veil. Posterior portions of the body sloping rapidly downward from the cardiac region in front of the branchiae into the highly arched, short, bluntly pointed tail.

*Rhinophores* stout, club-shaped, the stalk conical, expanding above into a broader clavus directed backward and in turn tapering above to a blunt tip, the length of the clavus nearly the same as that of the stalk. Clavus perfoliate with about 18 plates. Rhinophores retractile within conical smooth-rimmed sheaths.

*Mouth* full-lipped, rounded, at each side continuous into the oval tentacles. Oral tentacles auriform, directed outward and forward, the base cylindrical, the outer half deeply grooved on the upper side and transformed into a rolled plate, truncate at the top, with a wavy, sinuous margin. Greatest diameter of tentacles equals one-half their total length.

*Branchiae* on posterior dorsum arranged in a circle about the conspicuous cylindrical anal papilla in five tripinnate divisions arising from separate bases and non-retractile into a pocket. Anterior plume median, unpaired, the remaining four paired and laterally placed. Renal opening an inconspicuous pore on the right anterior side of the base of the anal papilla.

*Color* of back and sides yellow-brown, usually of a very deep shade, but in some specimens quite light. Dorsum and sides of body everywhere thickly set with small pale-blue round or oval spots, each one forming the center of a slight polygonal eminence bounded by narrow orange-yellow lines upon the dark-brown background. Foot orange-yellow with fine dark-brown flecks save at the margins, which are deep orange, shading off above on the sides into the deep yellow-brown of the dorsum. In small specimens the general colors are usually paler, tending to a light orange, the light blue spots being smaller and less conspicuous. Frontal and dorso-lateral processes and tips of branchial plumes bright orange or vermillion, shading below into dark brown. Stalk of rhinophore yellow, leaves and antero-median line of clavus and margin of the rhinophore sheath edged with bright orange-red.

*Pharyngeal bulb* very large and strong, conical, slightly compressed laterally, the radula sheath projecting behind and below as a rounded elevation. Labial disk oblique, oval, somewhat convex, the opening of an inverted-T or -Y shape. Cuticula not thick, colorless, prolonged inward to form the tubular mouth lining, its sides continuous with the dark-yellow, triangular, mandibular plates characteristic of the genus. The plates are broadest above, the nearly equal dorsal and anterior margins meeting at a right angle, and are made up of short, flexible, blunt, cross-striated rodlets, having a diameter of about 0.003 mm.

*Radula* broad, deeply grooved, light yellow, made up of about 14 rows of teeth. Rachis broad, bearing four rows of rudimentary (spurious) teeth. The two innermost rows are approximately quadrangular in form, colorless, the anterior margin thickened and fairly smooth. These plates increase in length from the anterior end of the radula backward, and also increase somewhat less rapidly in width, the general quadrangular shape being maintained. The outer row of rachidial plates is made up of flattened, triangular elements, increasing slightly toward the posterior end of the radula. They are about equal in length and breadth, and bear a more or less extensive thickening in the inner central region, the posterior end of which is occasionally prolonged into a slight though distinct cusp. Pleural teeth four in older portions of the radula, usually five to-

wards the sheath, large, strongly hooked, of nearly the same size and shape, the shaft with a vertical, wing-like expansion on its postero-dorsal half. (Pl. 31, figs. 20, 21.) Uncini seven to eight in number, the first ones slightly prismatic in form, gradually becoming reduced to elongate flattened plates, the first four or five of nearly the same size, then decreasing rapidly to the outermost ones. A well developed longitudinal crest, directed toward the median line and slightly overlapping the adjacent tooth, is borne by all except the outermost two or three uncini.

*Reproductive system.* (Pl. 31, fig. 19.) The hermaphroditic gland covers the anterior upper face of the liver, its duct arising from the upper surface close to the pyloric end of the stomach by the union of two main branches, which are lost in the fine ramifications in the substance of the gland. The duct is short, dilating into the long convoluted whitish ampulla which courses forward, passing beneath the anterior genital mass in a series of loopings in a groove between the nidamental gland on the right and the large spermatheca on the left. The total length of the ampulla is about 12 mm., nearly one-half the total length of the whole animal. At the anterior face it passes into the nidamental gland, giving off the spermatid duct, which emerges from the substance of the gland and at once dilates into the thick lobulated prostate gland.

This organ is broad and describes an S-shaped loop upon the anterior and inner faces of the anterior genital mass, forming with the spermatheca, which it closely covers, fully one-half of the bulk of the mass. Its distal end passes into the narrow muscular vas deferens. This doubles outward upon itself and courses obliquely forward and outward, dilating into the preputium, a cylindro-conical structure 2.5 mm. long and 1.5 mm. in its greatest diameter. At its base projects the blunt glans penis, armed with minute hooks.

The vagina is short and cylindrical, passing straight inward for 2.2 mm., when it makes a sharp turn posteriorly and, tapering for 1.5 mm., passes into the much narrower vaginal duct which, with a length of 1 mm., opens into the spermatheca upon its upper face. The spermatheca is a large spherical organ, 2 mm. in diameter, its anterior lower and inner faces nearly covered by the loops of the large prostate gland which also overlaps a portion of its upper surface. The exit of the uterine duct from the spermatheca is 1 mm. distant from the entrance of the vaginal duct and is situated upon its anterior face. The uterine duct is slender and passes downward and outward, being completely concealed by the overlying lobules of the prostate. It is about 2.5 mm. in length, and just before entering the nidamental gland receives the duct of the spermatocyst, a small pear-shaped sac lying upon the upper anterior face of the anterior genital mass, its surface exposed between the distal portion of the vas deferens and the top of the prostate gland.

The nidamental-albumen gland complex is small, about 2.5 mm. in length, 2 mm. in height, and 1 mm. in thickness. Its outer surface is convex, the inner irregularly faceted. The gland is about equally divided between the albuminous and nidamental portions, the former occupying the upper and the latter the lower portions, respectively. The relations of the ducts are as usual.

*Dimensions.* The largest specimen taken had a total length of 52 mm., breadth 10 mm., and height 11 mm., though the majority of individuals are much smaller than this, averaging perhaps 30 to 40 mm. in length.

*Habitat.* On *Laminaria* and *Fucus* in early summer in rocky tide pools all along the coast of Monterey Bay and vicinity north to Crescent City, south to La Jolla. Abundant everywhere during the summer months in rocky tide pools. Not so abundant in winter, but never entirely lacking.

### *Triopha grandis* MacFarland

Plate 19, figures 1, 2; plate 31, figures 22-26

*Triopha grandis* MACFARLAND, 1905. Proc. Biol. Soc. Washington, vol. 18, p. 50. MACFARLAND, 1906. Bull. U.S. Bureau of Fisheries, Washington, vol. 25, pp. 139-141, pl. 19, figs. 60-64; pl. 28, fig. 19. COCKERELL, 1915. Journ. Entomol. and Zool., Pomona College, vol. 8, no. 4, p. 299. O'DONOGHUE, 1922. Proc. Malacol. Soc. London, vol. 15, nos. 2, 3, pp. 136-138. O'DONOGHUE, 1927. Journ. Entomol. and Zool., Pomona College, vol. 19, pp. 97-98, pl. 2, figs. 48-50.

*Body* large, limaciform, plump, not at all depressed or compressed, highest in the heart region and sloping rapidly backward to the tip of the short blunt tail, more gently sloping forward.

*Head* flattened above, with a conspicuous semicircular frontal margin bearing 8 to 12 tuberculate or branched processes, and extending laterally beyond the region of the rhinophores.

*Dorsum* arched, smooth, passing abruptly down into the sides with no line of demarcation save a row of four to six dorso-lateral processes, tuberculate or with short branches, similar to those of the frontal margin but longer, the largest reaching a length of 8 to 10 mm.

*Dorso-lateral papillae* borne on an obscure lateral ridge continuing around into the frontal veil. Those behind the rhinophores have typically a main blunt inner tip curving upward and inward toward the middle of the back. Upon the outer face of its curve are borne several short blunt papillae. Within, the main tip is seen in white dim outline, a white mass, probably the "lens" of Fewkes. This shows no especial sensibility to light or touch. The velar papillae are much more sensitive to touch. (Pl. 31, fig. 24.)

*Foot* linear, abruptly rounded in front, gradually tapering behind to the bluntly pointed tail.

*Rhinophores* fairly large, perfoliate with about 20 leaves, the stalk stout, conical, the clavus conical, inclined backward, the whole organ completely retractile within conspicuous cylindrical sheaths with smooth slightly flaring margins.

*Branchiae* five, large, wide-spreading, tri- and quadripinnate, their bases entirely separate, arranged in a circle on the posterior mid-dorsum around the conspicuous cylindro-conical anal papilla, the small slit-like renal pore situated on the base of the latter on its right anterior side.

*Oral tentacles* short, blunt, auriform, their outer halves slit lengthwise along the upper surface. (Pl. 31, fig. 25.)

General *body color* varying from pale yellow-ochre to dark yellow-brown, flecked everywhere on the dorsum and sides with rounded light-blue spots, or they may be entirely absent, the tips of the processes of the frontal margin and dorso-lateral line, the tips of the branchiae, tip of the tail, and the margin of the rhinophore sheaths are vermilion or the more subdued burnt sienna.

Six specimens were brought to the Hopkins Marine Station from kelp beds in June of 1947 by Mr. Allyn Smith. The pale yellow-ochre body color was modified with lemon yellow and light red. Foot pale yellow. Of the six specimens studied, three were pale ochre, the two largest were the same yellow deepened by the use of brown, and the small specimen was quite dark, yellow-ochre with the addition of dark brown. Burnt umber could be used for extremely dark specimens. (Pl. 19, figs. 1, 2.)

The surface is covered everywhere with pale blue spots, most of which show a lighter apical area. Many of these are confluent in rows of two, three, or more, others isolated. These extend up the shafts of the dorsal lateral processes and up the main stalks of the gill divisions. The divisions of the branchiae, the stalks of the tuberculate processes, and the rhinophore stalks are translucent white.

*Labial disk* oval, but slightly convex, the opening vertical, in shape an inverted-Y. The labial cuticle continues laterally into the light-yellow mandibular plates occupying the upper sides of the mouth tube. These are elongate triangular in form, much smaller proportionately than those of other Monterey Bay species of the genus, occupying less than the upper half of the sides of the tube. Mandibular plates twice as long as broad, made up of short, slender, slightly curved, elastic, blunt rodlets from 0.002 mm. to 0.006 mm. in diameter, the longest at the dorso-anterior margin of the plate and decreasing in length behind and below.

*Radula* large, broad, deeply grooved, the deep amber teeth in 18 rows, the last two of which are immature. Rachis broad, with four series of flattened rudimentary plates (spurious teeth). The two more median rows of nearly equilateral rectangular form, the anterior margin smooth, the posterior one irregular, the anterior one-fourth thickened into a sharply defined transverse cutting ridge of a light-yellow color, contrasting strongly with the gray posterior three-fourths of the plate. At about one-third the length of this ridge, measured from the inner margin of the plate, it is joined by a fainter longitudinal ridge sloping toward the anterior margin; and in the posterior rows of the radula a similar longitudinal ridge toward the outer side of the plate may mark off a rectangular, elevated area. (Pl. 31, figs. 22, *a* and *b*, 23.) In the posterior portion



of the radula the region of the plate behind the transverse ridge tends to become convexly thickened in its inner median portion. Plates of outer series of the rachis are light yellow and triangular; the anterior inner angle is sharp and thickened, the other two are rounded and thinner. The antero-lateral border is thickened and slopes upward into a strong, rounded, longitudinal elevation, terminating posteriorly in a heavy blunt cusp, its apex forming a shoulder on the antero-lateral border, just below the anterior angle of the plate.

Pleurae with seven large, strong, amber-yellow teeth of similar form, strongly hooked, of nearly equal size. Body of each tooth long, obliquely placed, slightly curved and twisted at its lower end toward the median line of the radula. Hook large, directed slightly inwardly, and flattened dorso-ventrally with a broadly pointed, cutting edge. Basal portion of shaft with a small, inwardly directed, wing-like expansion.

Uncini eight, prismatic, amber colored, the shape of the inner ones resembling the bodies of the pleural teeth, with occasional indications of a rudimentary hook. Innermost four of nearly the same size, the outer four flattened and decreasing rapidly in size, the outermost being a colorless, almost rudimentary plate. A longitudinal wing-like crest projects toward the median line as in other Monterey Bay species of this genus.

*Hermaphroditic gland* large, concealing the liver; the hermaphroditic duct narrow at first, after a course of about 8 mm. passing into a very long, more dilated portion which is coiled in irregular corkscrew-like windings against the inner posterior flattened face of the large hemispherical mass formed by the nidamental and albumen glands. Straightened out, this duct measures about 60 mm., a length nearly equal to that of the whole animal.

This duct is the *hermaphroditic ampulla*. As it nears the anterior end of the genital mass it divides into the spermatic duct and the oviduct. The spermatic duct, with a total length of 20 mm. and a maximum diameter of 3 mm., passes almost directly into the prostate gland which is large, slightly flattened, and minutely lobulate.

Leaving the distal end of the prostate gland, the vas deferens, after a narrow portion of 2 mm., dilates gradually and passes into the penis sheath. This is 6 mm. in length by 3 mm. in width.

Upon its dorsal surface lies the small rounded *genital ganglion* borne upon a branch of the pleural commissure. The glans penis and the distal end of the vas deferens are closely set with minute, erect, claw-like hooks for a distance of about 2 mm., becoming more scattered and fewer toward the inner limit of their occurrence. (Pl. 31, fig. 26.)

The *oviduct* is as usual in the genus. The very large *spermatheca*, about 10 mm. in diameter, occupies almost the entire upper portion of the genital mass; its inner duct is short and receives the short duct of the 5 mm. pear-shaped spermatocyst, its distal portion, about 8 mm. in length, gradually dilates into the vagina.



*Radulae* of species of *Triopha*.

	No. of rows	No. of pleurae	No. of uncini
<i>Tr. modesta</i> Bergh	21-28	4-7	10-13
<i>Tr. carpenteri</i> (Stearns)	33	9-18	9-18
<i>Tr. maculata</i> MacFarland	14	4-5	7-8
<i>Tr. grandis</i> MacFarland	18	8	8
<i>Tr. eliotti</i> O'Donoghue	20-22	5(4-6)	8
(= <i>Tr. aurantiaca</i> Cockerell)			

*Dimensions.* The largest living specimen recorded, crawling freely, had the following measurements: length over all 147 mm., over all width 21 mm., height in front of gill 23 mm., height at rhinophores 14 mm., height posterior of gill 14 mm., width of expanded veil 20 mm., width of expanded veil plus the tubercles 32 mm., gill expansion width and length about the same, 45 mm., largest dorsal lateral papillae 8.5 mm. high. The net weight of two specimens was respectively 8.8 grams and 13.8 grams.

*Paintings.* (Pl. 19, figs. 1, 2, life size.) The specimen used was one collected by Allyn Smith in 1947, which had the following dimensions: length 130 mm., extreme width 28 mm., height at heart 25 mm., gill 75 mm. posterior from anterior margin of head. Gill expanded 40 mm., rhinophores 15 mm., longest mantle processes 10 mm.

*Habitat.* Upon the brown-kelp beds of *Nereocystis* and *Macrocystis* off the rocky coastline of Monterey Bay and vicinity. Never found in shore-line tide pools. Reported by O'Donoghue (1927) as taken in California by Hilton.

Genus **Polycera** CUVIER

*Themisto* OKEN. 1815. Lehrbuch Naturgeschichte, vol. 3, Zool., p. 278. *Non* Oken, 1807.

*Polycera* CUVIER. 1817. Règne Animal, vol. 2, p. 390; Ed. 2, 1830, vol. 3, p. 52; Ed. Voight, 1834, vol. 3, p. 117. ALDER and HANCOCK. 1846. Monogr. Brit. Nudibr. Moll., pt. 2, fam. 1, pl. 23; pt. 4, 1848, fam. 1, pl. 24; pt. 5, 1851, fam. 1, pl. 22; pt. 6, 1854, fam. 1, pl. 17; pt. 7, 1855, pl. 46, suppl. figs. 20, 21.

**Polycera atra** MacFarland

Plate 18, figures 1-4; plate 31, figures 27-31

*Polycera atra* MACFARLAND. 1905. Proc. Biol. Soc. Washington, vol. 18, pp. 50-51. MACFARLAND. 1906. Bull. U.S. Bureau of Fisheries, vol. 25, pp. 142-143, pl. 20, figs. 65-72; pl. 21, figs. 105, 111; pl. 29, fig. 22. JOHNSON and SNOOK. 1927. Seashore Animals of the Pacific Coast. Macmillan Co., New York, p. 496, pl. 10, fig. 4.

*Body* limaciform, smooth, plump, highest in front of branchiae, sloping backward to the short pointed tail, slightly contracted in front of cardiac region, then somewhat expanded in the slightly flattened head.

*Head* rather high, sloping downward in front, bearing a moderately wide horse-shoe-shaped frontal margin, narrowed in the center, carrying four slender, tapering, pointed processes 2 mm. in length. Lateral to rhinophores the frontal veil is slightly dilated and carries one or two additional, quite pointed, angular processes. Continuing backward as a slightly elevated dorso-lateral ridge, it bears upon its edge five or more small pointed processes. As the ridge reaches the region of the branchiae, the highest point, it bears two compressed pointed tubercles, one slightly anterior, the other posterior of the gill, the latter sharp and large, and may be elongated into an angular process of varying length. The conspicuous lobe of *Polycera quadrilineata* is represented by this process. Posterior to the branchiae, the dorso-lateral ridges bear a few small points and unite in a single low median crest to the tip of the tail.

*Branchiae.* Eight to 11 simple pinnate, non-retractile into a pocket, tallest in front and decreasing regularly in size from before backward. Maximum width of each division about 1 mm., height 3 mm., the number ranged in 14 specimens from 8 to 11. The gill of the specimen from Newport Bay (pl. 18, fig. 3) shows a pair of very small branchiae on the posterior side but entire in every respect. The branchial divisions of this specimen each had 13 large plates from inside. Midway between the large plates are frequently found intermediate, lower, thinner plates. These are not half as high as the larger plates. (Pl. 18, fig. 4, *b*.)

*Rhinophores* stout, sheaths absent, the stalk conical, the clavus club-shaped, perfoliate with 8 to 12 leaves, inclined slightly backward.

*Tentacles* very short, lobiform. Foot linear, its anterior angles prominent.

*Reproductive openings* on the right side midway between the anterior margin of the head and branchiae.

*Anal opening* at the summit of a low cylindrical papilla in the center of branchial plumes, renal opening slit-like, at right and close in front of the anal papilla.

*Color.* The general body color everywhere is a pale gray with narrow or broader lines of black on the dorsum and sides. On the latter, occasionally, they form simple transverse connectives or a network on the sides of the head below the velar region. Two longitudinal dorsal bands between the rhinophores extend back to the branchial opening and forward close to the frontal margin, connecting in front of the rhinophores with an outer pair. The four bands continue back, forking in front of the branchial area, passing under the branchiae to the top of the dorsum where they merge (fig. 1). The parallel lines of the sides run lengthwise, usually in pairs, although they may be broken in part. Isolated small spots of black occur on the frontal veil at the bases of the processes.

The foot is a clear pale gray, while the thin narrow margin is outlined by a row of orange dots or rounded spots alternating with black spots above, these fusing partly into lines and appearing as prolongations of the longitudinal lines of the sides.

The black surrounding the branchial opening continues up to the outer edges of the plates surrounding them. (Pl. 18, fig. 4, *a*.)

Oblong orange spots occur everywhere between the paired lines, occasionally merging to form a continuous line on the center of the dorsum. A band occurs midway of the angular processes of the frontal veil, as also on the angular points of the dorso-lateral ridge.

On the outer face of the branchial plume, near the tip, is an orange spot; a large round one occurs on the bulge up from the base, while the inner face has a pale spot at its base upon the clear gray stalk. (Pl. 18, fig. 4, *a-b*.) The inner face of the rhinophore, at its base, has a large triangular orange spot just anterior to the eye. The color patterns of *Polycera atra* are most intricate but definite and constant.

Figure 1 of plate 18 shows a typical dark specimen such as occurs most frequently in Monterey Bay; however, it is also found in Newport Bay. The lighter colors are more frequent in specimens from southern waters as shown in the figures made from photographs (figs. 2, 3). Collections made at Cabrillo Point in 1918 were very light with reduced black bands.

The black pigmentation recorded for *Polycera quadrilineata* (Müller, 1776) is even more variable, the yellow always present, the black occasionally. (Alder and Hancock, 1845; Meyer and Moebius, 1865.)

*Mandibles.* Strong, light yellow, made up of two portions; the ventro-anterior cutting part and the dorso-lateral arched wings. The cutting portion, deep yellow-brown, strong and thick, its outer surface arched shield-like, the upper anterior ends approximated, rounded, the lower ends divergent, curved backward and upward. Dorso-lateral wing broad, its anterior margin strongly concave, its superior and posterior margins rounded, not reduced to a narrow process as in *P. quadrilineata*. (Pl. 31, fig. 29.)

*Radula.* Deeply grooved, of a rich amber color in posterior younger teeth, deepening to dark brown in anterior portion. Teeth in 9 to 11 transverse rows. Rachis naked, pleural teeth two, hamate, unequal, the first smaller than the second, alike in shape, the stout shaft flattened, slightly concave upon its inner surface, upon its outer margin a broad, triangular, wing-like expansion directed toward the median line of the radula. Lower end of the shaft rounded, the upper end bearing a large smooth hook. Uncinal teeth three, triangular, prismatic, decreasing in size from within outward. Each tooth bears a sharp longitudinal crest upon the upper two-thirds of the outer border from which the upper surface slopes inward, the crest decreasing in the second uncinus and disappearing in the third. The lower ends of the uncini rounded, narrowed, the upper part sloping inward. Rarely a fourth rudimentary one is present. (Pl. 31, fig. 30.)

*Prostate gland* of the genital mass very large. The glans penis truncately conical, armed with closely set rows of minute curved hooks. These are continued into the distal vas deferens. (Pl. 31, fig. 31.)

*Dimensions*, living specimens. Largest specimen of *P. atra* taken May, 1926, from hull of sardine barge, on *Bugula* colony. Length, when freely floating at surface, 43.0 mm., width of anterior end of foot 4.4 mm., length of body from velar mid-margin to anterior base of gill plumes 15.3 mm., length of gill plume base 5 mm., length from posterior end of gill plume base to tip of tail 21.8 mm.

Largest specimen of 1921, July 3, measured 32.6 mm. total length, 7.4 mm. maximum total height in cardiac region, maximum foot width 4.0 mm. when crawling freely. The average length is about 23 mm. Alcoholic specimens measure in length from 12 mm. to 19 mm.

*Habitat*. In rocky tide pools along the southern coast of Monterey Bay and beyond, upon brown algae and especially upon *Bugula* colonies upon which it feeds. Common at Cabrillo Point and also upon hulls of fishing boats where great numbers of small specimens were found and nidosomes were abundant. Taken at Newport Bay and La Jolla and San Diego regions. Nidosomes short coiled bands about 10 to 12 mm. long, abundant in summer months.

The structural characteristics of *Polycera atra* clearly separate it from any other species of *Polycera* hitherto described. The low extrabranchial appendages resemble those of *Palio pallida* described by Bergh (1880) from Alaskan waters, but the coloration, the long frontal processes, the mandibles, radula, and reproductive apparatus are all decidedly different.

### Subfamily ONCHIDORIDINAE

#### Genus *Acanthodoris* GRAY

*Acanthodoris* GRAY, 1850. Figures of Moll. Animals, vol. 4, p. 103. MACFARLAND, 1906. Bull. U.S. Bureau of Fisheries, Washington, vol. 25, p. 144. MACFARLAND, 1925. Nautilus, vol. 39, no. 2, pp. 49-65, pls. 2, 3; also no. 3, pp. 94-103, 1926.

#### *Acanthodoris brunnea* MacFarland

Plate 20, figures 5, 6

*Acanthodoris brunnea* MACFARLAND, 1905. Proc. Biol. Soc. Washington, vol. 18, p. 52. MACFARLAND, 1906. Bull. U.S. Bureau of Fisheries, vol. 25, pp. 146-147; pl. 20, figs. 81-88a; pl. 21, fig. 104; pl. 29, figs. 20-21. O'DONOGHUE, 1921. Trans. Roy. Can. Inst., Toronto, vol. 13, pt. 1, pp. 171-172, pl. 4, figs. 41-42. O'DONOGHUE, 1924. Trans. Roy. Can. Inst., Toronto, vol. 15, pt. 1, p. 24. MACFARLAND, 1925. Nautilus, vol. 39, pp. 53-55, pl. 2, fig. 7.

*Body* outline oval, convex, broadest in front about the region of the rhinophores, the mantle firm, thickly set everywhere with conical tubercles having rounded tips. Mantle margin broad and thick, everywhere covering the foot, except posteriorly, where the latter is broadly visible when the animal is in motion.

*Head* large, veliform, concealed by the mantle, continued laterally into the wide flat tentacles. Tentacles broad, recurved, bluntly pointed at tips, their anterior curved

margin thin. Mouth a longitudinal slit. Foot oval, nearly quadrangular, its anterior and posterior ends bluntly rounded. Rhinophores long, cylindro-conical, tapering to blunt tips, inclined forward and outward, perfoliate with 20-28 thin, slightly oblique laminae, the lowermost ones occupying the front of the clavus only, the stalk and clavus about equal in length.

*Rhinophores* retractile within low sheaths, the margins of which are prolonged into six to eight lobes resembling the dorsal tubercles but somewhat flattened.

*Branchial plumes* seven, wide-spreading, bipinnate, non-retractile into a branchial pocket or sheath, arranged in an incomplete circle about the median anal papilla on the posterior dorsum. About ten tubercles are included in the circle in addition to the anal papilla. Renal pore close to base of anal papilla at the right and in front.

*Labial disk* round, convex, its light-brown cuticle radially striated, the mouth opening elongate, slit-like with dilated ends. Labial armature of minute hooks arranged in a triangular area on the lower sides of the mouth tube, separated ventrally by a median, slightly concave, cuticular plate, its anterior end blunt and jagged, projecting freely beyond the labial armature.

*Pharyngeal bulb* strong, upon its upper surface a large, connate, thick-walled, muscular crop, spherical in form and constricted longitudinally into two symmetrical halves.

*Radula* narrow, deeply grooved, pale yellow, its formula 24-28 (6.7.1.0.1.6.7). First pleural tooth large, upright, compressed, its base quadrangular in lateral view, overlapping the outer, anterior margin of the first pleural tooth in the following row. Base strongly thickened below and in front, thinner behind, the posterior lamina being prolonged upward as a squarish, slightly thickened shoulder. Upper anterior angle of base prolonged as a strong slightly curved hook, its inner margin bearing 14 to 19 strong denticles along nearly its whole length. Ratio of hook length to total height is nearly 1 to 2.4. Outer pleurae six or seven much smaller, obliquely directed, similar in general form to first pleural tooth but much simplified.

*Color.* General color of dorsum brown, flecked with irregular blotches of black in varying amounts, scattered between the tubercles, numerous small spots of light lemon yellow, the mantle edged more or less completely with the same color. Branchial plumes light brown, marked on the inner surface with two longitudinal lines of dark brown, the tips of the branchiae lemon yellow. Rhinophores deep blue-black, tipped with pale yellow, the laminae edged with a very narrow line of white. Under surface yellow, the lower face of mantle, the head, tentacles, and sides of the body sprinkled with fine dark-brown or black dots. In alcoholic specimens the general dark color is well retained, the yellow tending to disappear.

*Dimensions.* Body 23 mm. long, 10 mm. wide. Rhinophore 6 mm. long.

*Habitat.* Dredged from hard sandy bottom in from 5 to 10 fathoms off Cabrillo Point and off the entrance to Monterey Harbor and from various similar localities along the south shore of Monterey Bay. Recorded by O'Donoghue (1921, 1924) from Vancouver Island region, British Columbia.

***Acanthodoris lutea* MacFarland**

Plate 32, figure 15

*Acanthodoris lutea* MACFARLAND, 1925. Nautilus, vol. 39, no. 2, pp. 60-65, pl. 2, figs. 2, 6, 8; pl. 3, figs. 3, 6.

*Body* oval, highly arched, nearly equally rounded in front and behind, slightly broader in region of rhinophores than elsewhere. Dorsum with thickly set, low, conical papillae, large and small intermingled, but in general the largest near median line, shorter and more slender ones toward margin.

*Head* broad, veliform, a broad, shallow, median notch in front, the outer angles produced as short triangular tentacles. Foot broad, anterior margin bilabiate with a slight median notch. Rhinophores erect, slightly divergent, the stalk inclining forward, the conical clavus and tip curving backward. Clavus perfoliate with 26 leaves, retractile within low papillate sheaths.

*Branchial plumes* nine, low spreading, non-retractile within pocket, in a nearly complete circle around the prominent anal papilla, 10 to 12 dorsal papillae also included within the circle. Renal pore as usual at right and close in front of the base of the anal papilla.

Mantle thick, densely spiculate everywhere. Spicules simple, pointed, slightly curved, some even hook-like. Longest spicules 1.6 mm. long, 0.15 mm. maximum diameter.

*Labial disk* cuticle thin and colorless, labial armature thin and colorless, occupying lower sides of mouth tube. Armature of minute, squarish, blunt hooks in longitudinal rows. Median cuticular plate represented by two, slender, diverging, almost thread-like structures, united behind but widely separated at their free, anterior ends. The whole labial armature is much less developed than in other Pacific Coast species of *Acanthodoris* and might be readily overlooked by one not familiar with its presence and appearance in other species.

Buccal crop rather large, spherical, separated into two symmetrical halves by a longitudinal depression, closely attached to the pharyngeal bulb.

*Radula* nearly colorless, the younger portion yellowish. Dental formula 34-39 (5-6:1·0:1·5-6). Rachis narrow, naked. First lateral erect, compressed; the base approximately quadrangular, thickened below and in front, prolonged above into a strong slightly curved hook, which is strengthened on its inner border by a strong thin-edged ridge two to four well-developed denticles midway of its length, below which an irregu-



larly serrate margin continues for a short distance, becoming smooth and more thickened as it merges with the base. Average proportion of hook length to total length of first pleural tooth in two specimens was as 1 to 2.35 and as 1 to 2.36. Outer lateral teeth five to six, oblique, similar to first lateral in general form, the second lateral reduced to a thin plate with a slight basal thickening which extends along the dorsal anterior margin, the thin ventral lamina extending out to the tip. Remaining laterals progressively smaller, showing a more pronounced basal and dorso-anterior thickening, their general form becoming roughly triangular. (Reproductive system; MacFarland, 1925, *Nautilus*, pl. 3, figs. 3, 6.)

*Glaus penis* conical, short, without a trace of an armature.

*Color.* General ground color of dorsum red-orange, the papillae deeper. Between the papillae everywhere sprinkled with minute dots of lemon yellow, the same sprinkling extending up the stalks of the rhinophores, the clavus of which shades into a deep red, its leaves edged with the same color. Head margin edged with deep red. Branchial plumes grayish white, ventral surfaces of foot and mantle and sides of the body red-orange. The color of the animal is strikingly conspicuous in the tide pool and, as seen from a distance, quite resembles a bit of orange peel.

*Dimensions* of Cayucos specimen. Length 22.5 mm., maximum width 14.8 mm., length of foot 18.4 mm., width of foot 11.5 mm., maximum height 6.6 mm. Length of Moss Beach specimen 17.5 mm., maximum width 9 mm.

*Habitat.* In rocky tide pools at extreme low tide. One specimen (the largest) taken at Cayucos, San Luis Obispo County, by Dr. Myrtle E. Johnson; another taken by the writer on Colorado Reef, off Moss Beach, south of Montara Point, San Mateo County, California. Rare.

The two localities from which the specimens of *Acanthodoris lutea* have been found are about 95 miles to the southward, and 50 miles to the northward of Monterey Bay respectively. Without doubt it will eventually be found nearer to or within the bay itself, since the habitat conditions are essentially the same. The form would seem to live well out in or beyond the intertidal zone, and the heavy surf ordinarily makes collecting in that area very difficult, while it also, together with the rocky character of the bottom, renders dredging impossible.

### *Acanthodoris columbina* MacFarland

Plate 32, figure 16

*Acanthodoris columbina* MACFARLAND, 1926. *Nautilus*, vol. 39, no. 3, pp. 94-100, pl. 2, figs. 5, 9, 10, 11; pl. 3, figs. 1, 2, 5. [Plates 2 and 3 were issued in No. 2, October, 1925.]

*Body* oval, highly arched, mantle margin thick, covering the foot completely save at tip of tail. Dorsum thickly set with slender, tapering papilla, reaching  $1\frac{1}{2}$  to 2

mm. in height, giving it a soft velvety appearance, but actually densely spiculate and firm everywhere. Dorsal spicules slender, pointed, slightly bent, the longest about 0.9 mm. in length.

*Head* wide, veliform, produced laterally as widely triangular tentacles directed backward. Foot margin unilabiate in front, bluntly tapering behind. Rhinophores directed outward and forward, perfoliate with 22 to 26 leaves, retractile into low thin-edged sheaths whose margins bear six to ten papillae similar to those of the general dorsum.

*Branchial plumes* nine, low spreading bipinnate in a circle surrounding the median dorsal anal papilla together with numerous low dorsal papillae.

*Labial armature* forming two triangular areas on the sides of the oral tube just within the mouth opening, the apex of each triangle directed upward and forward and nearly meeting its fellow, the two areas thus nearly surrounding the tube, being separated slightly above, and at their bases below by a median cuticular plate, rounded and widest at its posterior end, tapering forward, slightly concave and finely striated above, the anterior end bifurcated by a narrow cleft, the two tips thus formed projecting freely above the cuticular surface and blunted and worn. Elements of the lateral labial armature minute, blunt hooks in 30 to 35 longitudinal rows, the squarish cusp directed forward, irregularly denticulate or occasionally notched.

*Radula* nearly colorless, yellowish behind, the formula 40-43 (5·1·0·1·5). Rachis narrow, naked, first lateral tooth large, compressed, erect, the quadrangular base very strongly thickened below and in front, behind expanded as a thin lamina overlapping externally the anterior portion of the base of the following first lateral. Upon the upper anterior portion of the base is borne a stout slightly curved hook. Its tip is blunt, its posterior margin thin, the anterior edge thickened into a strong ridge on its inner face, prolonged downward as the anterior margin of the base, dying away above toward the tip, and bearing six to eight small well-marked denticles. Outer laterals five, oblique, small, compressed, somewhat triangular, antero-dorsal margin thickened into a hook-like expansion connected below with its base by a thin expansion.

*Glans penis* very short, blunt, no trace of any armature present, vaginal duct and vagina very long.

*Color.* Dusky brownish mauve, the dorsal papillae tipped with lemon yellow, each more or less deeply shaded with brown; rhinophore stalks brownish, sprinkled with small, lemon-yellow spots, none white, clavus deep vinous red sprinkled with small spots of lemon yellow; branchial plumes lighter, their tips deep vinous red. Upper margins of main stalks of the plumes and the beginnings of their larger branches bear a row of small, dead-white, rounded nodules; mantle edged all around with a narrow, continuous band of lemon yellow, ventral surface of mantle and foot paler, tending toward yellow-gray. In alcohol the yellowish marginal line disappears but the other colors, though paler, are preserved for some time.

*Dimensions.* The largest specimen measured, while living and crawling freely, 32 mm. in length, 15 mm. in width, and 9.0 mm. in height, the others being but slightly smaller.

*Habitat.* Rocky tide pools of Colorado Reef, Moss Beach, near Montara Point, San Mateo County, California. Rare, but six specimens were taken in 1922. Will probably be found in deeper water and farther southward and northward of the type locality.

In general mauve color this species resembles *Acanthodoris nanaimoensis* O'Donoghue of the Vancouver region, British Columbia. The dorsal papillae are white or yellowish in the Vancouver form, while in *Ac. columbina* they are brownish and tipped with lemon yellow. In the latter species the mantle margin is edged with lemon yellow, and the rhinophores are sprinkled with small flecks of the same color, thus giving marked color differences. In *Ac. nanaimoensis*, the radula formula is 35 (6·7·1·0·1·6·7) while that of *Ac. columbina* is 40·43 (5·1·0·1·5).

### Subfamily GONIODORIDINAE

#### Genus *Ancula* LOVÉN

- Ancula* LOVÉN. 1846. Index Moll. Scand., p. 5. ALDER and HANCOCK. 1854. Monog. Brit. Nudibr. Moll., pt. 6, genus 7, fam. 1, pl. 17, figs. 7-8; 1855, pt. 7, Synopsis p. 45, pl. 46, sup. fig. 22. MEYER and MOEBIUS. 1865. Fauna der Kieler Bucht. I, pp. 59-62, pl. (not numbered), figs. 1-8; pl. 4, figs. 1-11. MACFARLAND. 1906. Bull. U.S. Bureau of Fisheries, vol. 25, p. 147.
- Miranda* ALDER and HANCOCK. 1847. Monog. Brit. Nudibr. Moll., pt. 3, fam. 1, pl. 25.

#### *Ancula pacifica* MacFarland

Plate 21, figure 1; plate 29, figures 2, 3

- Ancula pacifica* MACFARLAND. 1905. Proc. Biol. Soc. Washington, vol. 18, p. 53. MACFARLAND. 1906. Bull. U.S. Bureau of Fisheries, vol. 25, pp. 148-149, pl. 20, figs. 89-92; pl. 21, figs. 93-96; pl. 30, fig. 23. GUERNSEY. 1912. First Annual Report Laguna Marine Laboratory, Pomona College, p. 75, fig. 39 G. JOHNSON and SNOOK. 1927. Seashore Animals of the Pacific Coast, p. 497, pl. 11, fig. 3.

*Body* slightly compressed, smooth, limaciform, highest in front of the branchiae, tapering posteriorly to the tip of the long, pointed tail, anteriorly sloping less rapidly to the high, bluntly rounded head. No frontal veil present, the tentacles short, slender, blunt, and slightly flattened.

*Rhinophores* non-retractile into sheaths, large, clavus perfoliate with nine leaves, stalk and clavus of equal length, at the base two long finger-like processes nearly as long as the whole rhinophore, directed obliquely forward and outward. (Pl. 29, figs. 2, 3.)

*Branchial plumes* three, bi- and tripinnate, arranged in a semicircle inclosing the anal papilla with the small renal pore close beside and in front of it. On either side of

the branchial plumes are four erect, blunt, club-shaped processes of the dorso-lateral margin, dilated above, and contracted at their bases.

*Foot* narrow, its sides nearly parallel, tapering behind to the tip of the long slender tail, the anterior end abruptly rounded.

General *color* (pl. 21, fig. 1) clear, translucent, yellowish white, a narrow median line of orange extending from between the rhinophores to the branchiae and continued behind the plumes along a slight crest to the tip of the tail. A similar orange line on each side marking the indistinct dorso-lateral margin, and extending from the rhinophores to the extrabranchial appendages, continued between their bases, and prolonged for a very short distance behind the hindmost one. Rhinophore leaves yellowish, the tip orange, outer ends of basal processes of rhinophores orange. Tips of main subdivisions of branchial plumes orange, upper third of extrabranchial appendages yellow, their tips orange.

*Labial disk* convex, nearly circular, armed with a light yellow, strong, spinous armature narrowing laterally and incomplete above. Each element of the armature has a broad curved base, bifid behind, in front rounded, from which arises a minutely serrulate blunt hook directed forward.

*Radula* narrow, colorless, its formula 35 (1·1·0·1·1), the teeth increasing in the younger rows to twice the size of those in the most anterior rows. Rachis naked except for a series of rudimentary, flat, quadrangular plates, slightly broader behind than in front, absent in the first eight to ten rows but constant in the posterior part of the radula. Length of average median plate 0.018 mm., its width 0.013 mm. First pleural tooth large, its irregular transverse base and concave, triangular, vertical body placed slightly obliquely to the median plane of the radula, its upper, inner margin thickened and bearing 11-17 recurved, sharp denticles, at the upper angle terminating in a strong recurved hook. Height of average first pleural tooth 0.084 mm. Second pleural tooth triangular, thin above and terminating in a strong apical hook (MacFarland, 1906, pl. 21, figs. 93-96).

*Glans penis* with an armature of extremely small hooks along its canal for 0.6 mm., in about 15 rows, the individual hooks 0.004 mm. high.

*Dimensions.* Length of large specimen 16 mm., width 2 mm., height 3.5 mm. The largest specimen yet taken measured 29 mm. in length, 4.8 mm. in width, and 6 mm. in height. This large specimen had six extrabranchial appendages on the left side and five on the right, some quite small. These extra appendages have been observed on several specimens, one taken in 1949 at Carmel Point had three on either side.

*Habitat.* On hydroids and bryozoa in tide pools left at low tide along the southern rocky coast of Monterey Bay and southward to Carmel Point. Rare. Graceful and slow in movement, rather active in confinement. Recorded also from Laguna and La Jolla, California (M. E. Johnson). Taken at Newport Bay in 1946.

### Genus *Hopkinsia* MacFarland

*Hopkinsia* MACFARLAND, 1905. Proc. Biol. Soc. Washington, vol. 18, p. 53. MACFARLAND, 1906. Bull. U.S. Bureau of Fisheries, vol. 25, p. 149. THIELE, 1931. Handbuch Syst. Weichtierkunde, vol. 1, pt. 2, p. 429.

### *Hopkinsia rosacea* MacFarland

Plate 21, figures 2, 3; plate 31, figures 32-36

*Hopkinsia rosacea* MACFARLAND, 1905. Proc. Biol. Soc. Washington, vol. 18, p. 54. MACFARLAND, 1906. Bull. U.S. Bureau of Fisheries, vol. 25, pp. 149-151, pl. 21, figs. 97-103; pl. 31, figs. 24, 25. O'DONOGHUE, 1927. Journ. Entomol. Zool., Pomona College, vol. 19, pp. 100-101, pl. 2, figs. 57-59. JOHNSON and SNOOK, 1927. Seashore Animals of the Pacific Coast. New York, Macmillan Co., p. 497, pl. 11, fig. 4.

*Body* outline elongate-elliptical, sometimes elongate-oval or almost quadrangular, the ends abruptly rounded. Much depressed and flattened, the dorsum but slightly arched above and sloping gradually outward to the thin margin of the foot, there being no trace of a pallial margin or ridge marking the boundary between back and sides. Dorsum firm, fragile, the many closely packed spicules rendering it almost calcareous. Spicules elongate spindle-shaped, short or long, covered with minute nodular projections giving them a rough surface.

*Foot* broad, abruptly rounded behind into a short and broad tail, in front truncate and deeply incised by a broad triangular notch, the margins of which are slightly thickened, the remaining margins of the foot and tail thin and undulating.

*Head* broad, its oral tentacles very broad, uniting in front, forming a veil-like expansion with thin undulating margin, the rounded posterior angles slightly auriculate and free from the outer anterior margin of the foot for a very short distance. The mouth a longitudinal slit.

*Dorsum* thickly set everywhere with long, gently tapering, soft papillae, many reaching a length of one-half to two-thirds the length of the whole animal, most abundant on the lateral portions of the dorsum and in front of the rhinophores, more sparse on the mid-dorsum. Papilla tips usually pointed and simple, but branching is not uncommon, the tip being bifid or the branch being borne along the side of the papilla. In some cases this may be due to a fusion of two or more papillae.

*Rhinophores* soft, non-retractile, perfoliate with about 20 leaves, cylindro-conical, tapering, the shaft passing upward into the clavus without a noticeable increase in diameter. Clavus nearly three-fourths the total length of the rhinophores, the plates borne on the lateral and posterior faces.

*Branchial plumes* 7 to 14, simply pinnate, non-retractile, soft, free from spicules, entirely separate at their bases, inclined obliquely backward, arranged in a wide semi-

circle or arc approximating horseshoe form in the median line of the posterior half of the dorsum, inclosing the low anal papilla.

*Renal opening* very small, close to right and in front of the base of the anal papilla.

*Reproductive openings* inconspicuous, on right side far forward, exterior to base of right rhinophore, and just below the outermost row of papillae.

*Color* everywhere a beautiful deep rose pink.

*Labial disk* armed with a ring of short, thick, closely set rodlets. Pharyngeal bulb short and thick, bearing on its dorsal surface an ellipsoidal muscular crop, the ingluvies attached by a very short and narrow stalk. *Radula* very narrow, its formula 16 (1·1·0·1·1). Rachis very narrow, naked. Single pleural tooth large, erect, long, flattened, its base broad, triangular, thickened above, the shaft of the tooth flattened, blade-like, the posterior border laterally beveled to a thin, sharp, slightly curved edge, the anterior margin straight, thickened and rounded. At the distal narrowed end is borne a small, posteriorly curved, blunt hook, frequently broken off and missing in the oldest rows of the radula, the whole tooth being more slender and narrower than in the younger posterior rows. Total height of average pleural tooth 0.63 mm., length of blade 0.339 mm., length of apical hook 0.036 mm. Single uncinal tooth much smaller, thin, depressed, nearly horizontal, triangular in general outline, the anterior lower end emarginate, the posterior one more or less pointed and often divided into irregular denticles. Quite variable in form and easily overlooked. Length 0.080 to 0.096 mm., greatest width 0.076 mm. (Pl. 31, figs. 32-34.)

*Prostate gland* very large, glans penis armed with minute hooks. Spermatheca large, spherical, spermatocyst quite small, elongate-oval.

*Dimensions.* Length of large specimen 28 mm., width 16 mm., height of body, alone, 5 mm. Length of longest dorsal papilla 18 mm.

*Habitat.* A strikingly beautiful nudibranch not rare among rocks at low tide at Pacific Grove, California, and the coastline adjacent to Monterey and Carmel bays. Recorded from San Pedro (Cockerell), La Jolla (Hilton), San Diego (Johnson and Snook).

#### Genus *Trapania* PRUVOT-FOL

*Drepania* LAFONT, 1874. Description d'un Nouveau Genre de Nudibranches des Côtes de la France. Journ. de Conchyl., ser. 3, vol. 14, (vol. 22), pp. 369-370; not Hübner, 1816. Type, *Drepania fusca* Lafont. BERGH. 1881. Beitr. Monogr. Polyceraten, II. Verh. k. k. Zool.-Bot. Ges. Wien, 1880, pp. 635-638, pl. 10, figs. 10-15. VON IHERING. 1885. Beitr. Kenntnis Nudibranchien des Mittelmeeres, II. Malakozool. Bl. N.F., vol. 18, pp. 36-39, pl. 1, fig. 2; pl. 2, figs. 8, 9. MACFARLAND, 1929. *Drepania*, a Genus of Nudibranchiate Mollusks New to California. Proc. Calif. Acad. Sci., ser. 4, vol. 18, pp. 485-496, pl. 35.



- Trapania* PRUVOT-FOL. 1931. Notes de Systematique sur les Opisthobranches. Bulletin du Museum Nat. Hist. Nat., Paris, ser. 2, vol. 3, no. 8, p. 747. New name for *Drepania* Lafont 1874, not Hübner, 1816.
- Drepanida* MACFARLAND. 1931. *Drepanida*, new name for *Drepania* Lafont, pre-occupied. Nautilus, vol. 45, no. 1, pp. 31-32. (Antedated by *Trapania*, Puvot-Fol, June, 1931.) THIELE, 1931. Handb. Syst. Weichtierkunde, vol. 1, pt. 2, p. 429.

### *Trapania velox* (Cockerell)

Plate 20, figures 1-3; plate 32, figures 17-24

*Thecacera velox* COCKERELL. 1901. Three New Nudibranchs from California. Journ. Malacol., vol. 8, no. 3, p. 87.

*Drepania velox* (Cockerell), MACFARLAND, 1929. *Drepania*, a Genus of Nudibranchiate Mollusks New to California. Proc. Calif. Acad. of Sci., ser. 4, vol. 18, no. 15, pp. 487-496, pl. 35, figs. 1-15.

*Body* limaciform, slender, smooth, arched above, the sides but slightly set off from the foot margin.

*Foot* slender, linear, margin set off from the sides of the body as a narrow thin ridge. Edges of foot closed together when floating. Its anterior angles produced into long, tapering, blunt processes, slightly grooved ventrally throughout their full length, in life kept in active, tactile motion. Anterior margin broadly emarginate, the median portion bearing a series of very small whitish papillae directed forward.

*Head* rounded, anterior tentacles long, tapering, the ends blunt, not used actively as tactile organs, but held in a more rigid position than the processes of the foot, and more comparable to the velar processes in *Polycera*.

*Mouth* an inverted-T shape.

*Rhinophores* clavate, tapering above to blunt points, perfoliate with 10-12 leaves, the stalk short. External to the base of each rhinophore is borne a horizontal, blunt, cylindrical process, two-thirds the length of the rhinophore, curving laterally around its base toward the mid-dorsum and exhibiting but slight movement.

*Branchial plumes* three, nearly midway of dorsum, inclined slightly backward, bipinnate or simply pinnate, non-retractile into sheaths. Immediately in front of the branchiae and at either side of the median line arises a finger-like, blunt, tapering process which curves horizontally backward around and behind the plumes.

Ground *color* of living animal everywhere clear and transparent, gray when viewed over a dark color, a decided cream when over white. The terminal third of the rhinophores and of their basal processes, nearly the whole of the anterior tentacles, the tips of the branchiae, the terminal third of the extrabranchial appendages, and the tip of the tail a deep rich orange-yellow.

A narrow median line of very dark brown (van dyke) extends from the frontal margin backward, interrupted or not, between the rhinophores to the cardiac elevation

in front of the branchiae, there joining a crescentic, transverse, dark-brown band extending along the dorsal surfaces of the extrabranhial appendages about two-thirds of their length. Behind the branchiae a median stripe of dark brown extends nearly to the tip of the tail. A narrow, dorso-lateral band of this same color on each side extends from immediately behind the basal process of the rhinophore nearly to the tip of the tail, being interrupted opposite the base of the extrabranhial appendage. Along each side of the body a band of dark brown extends from immediately behind and below the anterior tentacles along the body parallel to the foot toward the tip of the tail, with slight interruptions. These dark red-brown lines vary in width along their extent and may be interrupted by slight breaks of continuity in some specimens or may be continuous throughout. Midway between the rhinophores and the branchiae, on either side of the median stripe, is a short stripe of dark brown.

A median dorsal stripe of dark brown is often borne upon each basal appendage of the rhinophores, extending from its base to the terminal orange extremity. The axis of each branchial plume bears a short, oval, linear or irregular spot of dark brown upon its outer basal surface. (Pl. 32, fig. 23.) The brown lines on the dorsum are somewhat broken, margins not even but irregular. The color occurs in masses of dark red-brown.

In alcohol the dark stripes persist, the orange color becomes much paler.

*Oral tube* short and wide, its opening a vertical slit guarded above on either side by a triangular mandibular plate made up of short pointed spines directed forward. (Pl. 32, fig. 21.) Pharyngeal bulb bearing a large, nearly hemispherical, sessile ingluvies or crop.

*Radula* short and rather broad, its formula 24 (1·0·1). Rachis naked, the pleural tooth strongly convex in front, concave behind. The narrow crescentic base is placed obliquely upon the basal membrane, slanting inward and backward toward the median line. The body of the tooth is a shell-like, convex, irregular plate, the outer angle of which is prolonged as a strong, curved, pointed cusp, the inner sloping margin bearing a series of some 8 to 11 unequal sharp denticles forming an irregularly jagged serrate ridge. (Pl. 32, figs. 18-20.)

*Reproductive system.* Vas deferens long, thick-walled, glandular throughout save at its proximal and distal ends, preputium moderate in length, the cylindro-conical glans penis bearing a lumen armature of closely set curved spines, their points directed outward. Of these the longest form a narrow zone farthest away from the tip; succeeding them is an intermediate zone of spines of about one-half the height of the longest, and these are followed by a distal band of longer and more slender hooks. This armature is probably eversible (MacFarland, 1929, pl. 35, fig. 12).

*Dimensions.* Length of three living specimens when crawling freely measured 15 mm., 22 mm., and 25 mm.

One specimen had the following detailed measurements: length 20 mm., width 4.5 mm., tip of tail to gill pocket 8 mm., pocket 2 mm., anterior to rhinophores 8 mm.,

base of rhinophore to anterior margin of head 2.5 mm., oral processes 2.5 mm., anterior tentacle 2 mm., rhinophore 3.7 mm. long, basal process 2.2 mm.

*Habitat.* One specimen taken in a tide pool at La Jolla, California, by Dr. Myrtle E. Johnson; the single specimen described by Professor Cockerell as *Thecacera velox* was also taken at La Jolla. Four specimens taken on hydroids and algae, later, in 1947, by Mrs. Nettie MacGinitie from landing float; two others were collected in the same locality at Corona del Mar, California. Three fine specimens were received in July, 1948, from G. E. MacGinitie. (Pl. 20, models for figs. 1, 2, 3.)

Apparently it is not common, but extended collecting should secure more.

The genus *Drepania* was founded by A. Lafont in 1874 upon the species *Drepania fusca* Lafont, taken at Arcachon on the southwest coast of France. A second species, *Drepania graeffei* Bergh, was described in 1881 from Trieste, in the northern Adriatic, and a third one, *Drepania tartanella* von Ihering, from the Bay of Naples was described in 1885 by the latter author. These two are so closely allied that they may best be regarded as one and the same species. The California species was described as *Thecacera velox* by Cockerell in 1901, but was not satisfactorily studied until 1929, when the present writer (MacFarland, 1929) gave a somewhat detailed account and showed its true status, overlooking, however, that the name *Drepania* had been pre-occupied by Hübner in 1816. In a later note, July, 1931, he called attention to this fact, and proposed the name *Drepanida* for the genus. Unknown to him, however, one month previously Mme. A. Pruvot-Fol had proposed the name *Trapania* for the same genus, and her name has priority and should be recognized as the correct one.

Baba (1935, pp. 236-238) described a new species, *Trapania japonica* Baba, from Mutsu Bay, Japan, which seems clearly distinct from the European and California species.

The genus at present contains the following species:

1. *Trapania fusca* (Lafont, 1874). Genotype, Arcachon, France.
2. *Trapania graeffei* (Bergh, 1881). Trieste. Synon. *Trapania tartanella* von Ihering, 1885, Naples.
3. *Trapania velox* (Cockerell, 1901). La Jolla; Corona del Mar, California.
4. *Trapania japonica* (Baba, 1935). Mutsu Bay, Japan.

## Family CORAMBIDAE

### Genus *Corambe* BERGH

*Corambe* BERGH, 1869. Bidrag til en Monograph om Phyllidierne Naturhistorisk Tidsskrift, 3 R. V. B.; in a footnote on page 359, Bergh mentions for the first time the new genus *Corambe*. BERGH, 1871. Beiträge zur Kenntniss der Mollusken des Sargassomeeres. Verh. d. k. k. zool.-bot. Gesellschaft Wien, Bd. 21, pp. 1293-1297, pl. 11, figs. 21-27; pl. 12, figs. 1-11. FISCHER, P., 1888. Note sur la présence du genre *Corambe* Bergh, dans le bassin d'Arcachon (Gironde).

Bull. Soc. Zool. France, vol. 13, no. 9, pp. 215-216. FISCHER, H., 1891. Recherches anatomiques sur un Mollusque appartenant au Genre *Corambe*. Bull. Sci. de la France et de la Belgique, vol. 23, pp. 358-398, pls. 9-13. BERGH, 1892. System der Nudibranchiaten Gastropoden. Wiesbaden. Semper's Reisen im Archipel der Philippinen. Wissenschaftliche Resultate. Malakologische Untersuchungen, Bd. 3, H. 18, pp. 166-168. FISCHER, H., 1896. Note sur la distribution du Genre *Corambe*. Journ. Conchyl., vol. 43, pp. 235-236. VAYSSIÈRE, 1901. Étude comparée des Opisthobranches des Côtes Françaises de l'Océan Atlantique et de la Manche avec ceux de nos Côtes Méditerranéennes. Bull. Sci. France et Belgique, vol. 34, p. 296. MACFARLAND and O'DONOGHUE, 1929. A new species of *Corambe* from the Pacific Coast of North America. Proc. Calif. Acad. Sci., ser. 4, vol. 18, no. 1, p. 3.

### *Corambe pacifica* MacFarland and O'Donoghue

Plate 22, figures 6-8; plate 29, figure 20; plate 32, figures 13, 14

*Corambe pacifica* MACFARLAND and O'DONOGHUE, 1929. Proc. Calif. Acad. Sci., ser. 4, vol. 18, no. 1, pp. 1-27, pls. 1-3.

Animal elliptical, flattened, disk-like, slightly arched in the central region of the body.

The *notaeum* everywhere extending beyond the foot, its margin wide and thin, entire save for a deep, median, rounded notch behind. The notaeum is very thick, slightly less so in the median area than at the sides. The low cuboidal epithelium of the dorsal surface secretes a thick cuticular layer, which shows distinct stratification in sections. Without doubt the dorsal cuticle of the notaeum is periodically shed as a continuous sheet and renewed, lines of cleavage parallel to the surface being shown in sections. The detached entire cuticle is frequently found in aquaria, while the animal is still covered with the partially free cuticle.

*Foot* equally rounded in front and behind, its anterior margin with a deep median notch revealing the mouth in the angle.

*Head* small, covered entirely by the notaeum, its angles prolonged into short blunt tentacles, directed outward and forward, their tips showing beyond the notaeum margin when the animal is crawling freely.

*Rhinophores* retractile within low, entire, smooth-margined sheaths, the lower half of the stalk cylindrical, nearly filling the sheath, tapering rapidly above to a narrower shaft with blunt apex. From the anterior and lateral faces of the stalk arises a revolute, vertical, plate-like expansion inclosing the upper portion of the shaft and extending nearly to its tip in front, its superior margin sloping rapidly downward laterally and fusing with the shaft behind, leaving a small portion above free.

Within this outer envelope so formed, and attached to it in the median line in front below, the shaft bears a pair of smaller, lateral, revolute plates whose free, nearly vertical, hinder margins approach each other behind but do not unite. Along the median posterior face of the stalk a low unpaired third vertical keel-like ridge or plate is borne, nearly as long as the inner paired lateral ones. Above the upper ends of these

plates the sub-conical tip of the stalk extends and terminates in a blunt apex. (MacFarland and O'Donoghue, 1929, pl. 1, fig. 2.)

*Branchiae*, a series of simple pinnate plumes borne upon the under surface of the notaeum margin ranging in number in mature individuals from 6 to 14 borne on either side of the median anal opening between the foot and the notaeum, decreasing in size from behind forward, and limited to the posterior third of the sides of the body. A single median plume may be situated immediately above the anus. (MacFarland and O'Donoghue, 1929, pl. 1, fig. 5.)

*Lamellae* of longest plumes 10 to 20 in number, opposite in arrangement, upon the sides of a horizontally flattened shaft; just above the insertion of the branchiae a series of large simple alveolar glands alternating with the bases of the plumes and of nearly the same number.

*Anal opening* at the posterior end of the body in the median line immediately below the notch of the notaeum margin; close to it, at the right and slightly above it, is the simple renal opening, a minute pore.

*Reproductive openings* three, far forward on the right side, between the notaeum and the foot.

Ground *color* of notaeum pale translucent gray, the central area marked out by the very pale orange-yellow color of the liver showing through the integument. Surrounding this central area is a lighter zone determined largely by the foot showing through from below. Outside this zone, and nearly equal to it, is the nearly transparent notaeum marginal zone. It is marked with irregular continuous and discontinuous lines of clear pale yellow-ochre arranged radially. Toward the center of the dorsum these lines become broken up into dots of color and are more irregularly scattered. These radial lines with their cross connections resemble the walls of the *zoecia* of the bryozoan *Membranipora* to a very marked extent. Between the superficial yellow markings are larger and smaller flecks, in general radial in arrangement and lying deeper in the integument. These are largest and most numerous in the second zone and become smaller and more rounded in the central area. The central and major portion of each fleck is indian red or garnet in color, and is usually edged with an incomplete narrow line of darkened garnet, almost black. Around the rhinophore bases they may form an almost continuous ring, but are usually clearly separate. Scattered, small, black flecks may also occur in the median area. In darker specimens the garnet spots are larger and more numerous, especially in the median region, their borders deepening to a greenish color when not black. Foot clear gray with a narrow, white, marginal line. Rhinophores clear, translucent gray, the sheath either the same or with a few spots of garnet, yellow, or black. The stalks of the gill divisions sometimes show spots of color.

A more perfect example of protective coloring would be difficult to find as this animal so perfectly matches its habitat in markings and color.



In alcoholic specimens the color disappears with the exception of scattered black points.

*Radula* formula, 38-40 (4.5:1.0:1.4-5). Median tooth wanting, first lateral large, compressed, its base roughly quadrilateral, large, erect, bearing upon its anterior upper angle a large, slightly curved hook having three to seven denticles upon its inner margin. Upper, posterior angle of base thickened and bluntly pointed, forming a second minor hook directed backward. Inner face of base with a low, recurved, wing-like lamina arising behind and below the lowermost denticles and curving downward and forward to the insertion of the base. Outer lateral teeth usually four, decreasing in size progressively outward, each consisting of a broad rounded base bearing a slightly curved, simple, pointed, triangular hook, rounded above and supported below by a median lamina. Rows of teeth not exactly opposite each other in the lateral halves of the radula.

*Pleural ganglia* not fused with the cerebral, but united to them by short connectives. The central nervous system is most fully described and illustrated in the publication cited.

The *reproductive system* is also treated in detail in the above publication, agreeing, in the general organization, with the description of H. Fischer for *Corambe testudinaria*, with the exception of the existence of a spermatocyst for *Corambe pacifica*.

*Dimensions.* Specimen used in making water-color figure. Large size, 13 mm. long, 10 mm. wide crawling freely, taken in 1949. Rhinophore 1.6 mm. long. Between rhinophores 2 mm. A smaller specimen is 6 mm. in length by 4.5 mm. in width.

*Habitat.* Upon brown kelps, mainly *Macrocystis pyrifera* (Linnaeus) Agardh, *Nereocystis luetkeana* (Mertens) Postels and Ruprecht, and upon *Zostera marina* Linnaeus, bearing incrustations of *Membranipora villosa* Hincks colonies upon which the mollusks feed. They are seldom separated from these colonies and then probably through accident. Monterey Bay, California. Nanaimo, British Columbia.

*Holotype.* No. 6859 (California Academy of Sciences Department of Geology Type Collection), collected May 21, 1928, by F. M. MacFarland in Monterey Bay, Pacific Grove, California.

#### Genus *Corambella* BALCH

*Corambella* BALCH, 1899. Proc. Boston Soc. Nat. Hist., vol. 29, no. 7, pp. 151-153, pl. 1, figs. 12-15.  
THIELE, 1931. Handb. Syst. Weichtierk., vol. 1, no. 2, p. 430.

The genus was erected by Balch in 1899 to receive a form collected by him at Cold Spring Harbor, Long Island, which seemed closely allied to *Corambe* Bergh, 1871, but differing in important particulars.



Unfortunately Balch was not able to compare his type species, *Corambella depressa*, with *Doridella obscura* Verrill, 1873, having only the original fragmentary description at hand, and details of the latter have not been published. Until such studies are made, its exact relationship with *Corambe* and *Corambella* must remain in doubt.

A singular statement by Balch that the external reproductive openings are on the left side of the body instead of the right side as in all nudibranchs, and so figured by him (pl. 1, fig. 14), seems to have been overlooked by subsequent writers. This is true, likewise, regarding the inaccuracy of the radula description and the figures of the teeth (pl. 1, fig. 15).

Fortunately, specimens are now at hand for study, received from F. B. Sumner of the U. S. Fish Commission, from the Wood's Hole collection, namely eight specimens of *Doridella obscura* Verrill, 1873. These were collected off Gay Head from floating seaweed, July 10, 1904. The lengths ranged from 2 to 5 mm., widths 1.5 to 3.2 mm. Disposition of this material was as follows: two specimens were stained in toto. Three were left unstained. The gills of these five specimens were transverse lamellae and seemed similar to those figured by Bergh for *Corambe sargassicola*. The remaining three specimens were used for serial sections, cut in three planes. Careful study followed. Some results are stated herein.

*Bodies* elliptical, highly arched, the mantle margins thick, entire, the surface smooth. The cuticle had become completely detached from one specimen. Rhinophores withdrawn into wide sheaths.

*Foot* elliptical, pointed slightly behind, narrower than the dorsum in front with a deep notch. There is no medial posterior notch in the mantle as figured by Fischer for *Corambe*.

The *mouth* tube lining is much folded into close ridges of covered cuticle; surrounded by closely packed glands. The longitudinal series shows the labial glands to be more abundant than in *Corambella bolini*. The mouth tube, in cross section, shows the cuticle thickening at both sides of the bulb opening, forming a longitudinal short plate.

The *gills* in the longitudinal series are in the form of two transverse elongated parallel plates each of which bears, on the upper and lower surfaces, a series of shorter, nearly vertical platelets, alternating in position. The upper plate is the larger and bears eight alternating platelets on either side, the shorter lower plate bears five platelets on each side. The preparation does not show the true character clearly. At the base of the gill is found a series of large alveolar glands opening above the base of each gill plate.

The cerebral nerves to the rhinophores, to both eyes with their ganglia, genital papilla, lateral salivary gland, and oesophagus all show as the sections are studied from the anterior backward. The radula teeth are well shown *in situ* on the sides of the groove, the tips directed inward.

**Corambella bolini** MacFarland, new species

Plate 22, figures 9-11; plate 29, figure 21; plate 32, figures 1-12

This new species has been found in abundance associated with *Corambe pacifica* MacFarland and O'Donoghue upon the same *Membranipora membranacea* colonies borne on the large brown kelps off the southern coast of Monterey Bay. At first sight the two may be deemed identical, but closer examination reveals marked differences.

*Body* doridiform, elliptical, depressed, and flattened, the notaeum nearly smooth, rather convex in median area, its margin wide and entire, extending well beyond the *foot* all around, no median notch behind as in *Corambe*; the *foot* smaller than the notaeum, its anterior margin rounded or but slightly emarginate, the narrowed posterior blunt tip showing from beneath the notaeum when the animal is crawling actively.

*Head* small, entirely concealed beneath the notaeum, its outer anterior angles prolonged into short, slender, tapering *tentacles* directed outward and forward, and extending beyond the notaeum margin in active motion when crawling freely.

*Mouth* a short longitudinal fissure surrounded by somewhat inflated lips.

*Eyes* small, black, clearly visible deep down beneath the integument between and slightly behind the bases of the rhinophores.

*Rhinophores* from one-third to one-fourth the length of the body, smooth, tapering to blunt tips directed outward and forward, surrounded at the base by a rather high close-fitting sheath, the thin margin of which is smooth and entire, forming the boundary of the cavity in the notaeum into which the rhinophores are completely retractile. No trace of the wing-like lamellae characteristic of *Corambe* is present.

*Anal opening* in the posterior mid-line of the body, between the notum and the foot, the *renal opening* close above it.

*Reproductive openings* three, close together, far forward on the right side, slightly behind the plane of the right rhinophore.

*Branchiae* posterior on either side of the median anal opening, arising from the ventral surface of the wide marginal zone of the notaeum, two to three or four in number, the largest pair nearest the median line, the others decreasing rapidly in size outward. The largest innermost gill consists of a flattened, somewhat widely triangular stalk directed backward and downward bearing several (three or four) small flattened

lamellae upon its dorsal and ventral faces. The outer gills have fewer lamellae or may be represented by the flattened stalk alone. Near the bases of the gills where the under surface of the notaeum merges with the postero-lateral body wall is borne a crescentic series of large, simple alveolar glands, their secretion probably of a mucous nature, passing out through a separate duct from each alveolus close to the origin of the separate gills. (Pl. 22, fig. 10; pl. 32, figs. 10, 11, 12.)

*Color.* (Pl. 22, figs. 9, 10.) The thick notaeum is covered by a somewhat smooth transparent cuticle formed by the outer epithelium which increases in thickness from below. This is shed from time to time as a continuous layer, being replaced by the newer layers beneath. The general effect of coloration resembles that of the *Membranipora* colonies to a remarkable degree.

In general, the color is a translucent white. In dorsal view, the central areas of the notaeum are very pale yellow because of the viscera showing through. The surrounding peripheral zone is more translucent. The mid-dorsal area shows seven to ten irregular, narrow, broken, longitudinal lines of white, which have an encrusted appearance, borne upon ridges of the grayish background. These undulating lines are interrupted here and there and toward the outer zone become more irregular, knotted, and looped. They are replaced near the margin by very short, radial, nodular lines tending to form networks. Scattered between these white lines are spots, usually small, of dark red-brown or garnet quite uniformly distributed over the notaeum, becoming somewhat smaller toward the margin.

*Ventral surface.* General color whitish, the vague outlines of the viscera showing faintly through the foot as pale yellow.

No true *mandibles* are present. The pharyngeal bulb is lined by a strong homogeneous cuticula which is thickened at the anterior opening forming a ridge bounding its lower margin and extending backward ventrally behind the opening for a short distance toward the radula. A similar thickening has been noted for *Corambe sargassicola* by Bergh (1871) and Fischer (1888) and for *Corambe pacifica* by MacFarland and O'Donoghue (1929). This structure probably gave foundation for the statement by Bergh (1871) that mandibles were present. (Pl. 32, figs. 8, 9.)

*Radula* small, its formula about 40-60 (5·1·0·1·5), the teeth similar in form to *Corambe pacifica* but smaller. Rachis of the radula very narrow, naked, first lateral tooth compressed, the base rectangular, its upper angle forming a prominent point, a curved lateral wing-like prominence curving around ventrally and continued up on either side. The cusp or hook slightly curved, its pointed tip directed slightly medially, on its inner lower margin bearing a single series of three to eight small pointed denticles decreasing in size toward the base. (Pl. 32, figs. 1-7.)

Outer laterals four or five, their bases somewhat broad, rounded, bearing a simple curved pointed hook which in the older teeth may be absent as if worn away.

*Dimensions.* Living specimens.

11.0 mm. long	7.5 mm. wide
2.5 mm. long	1.75 mm. wide
3.0 mm. long	2.0 mm. wide

The smaller sizes were more common in June 10-18, 1949, though the larger ones were also taken in smaller numbers.

In general *Corambe* seems to be smaller than *Corambella*.

Alcoholic specimens range from 2.5 mm. to 5.0 mm. long by 1.5 mm. to 4.2 mm. wide.

*Rhinophore.* Measurements from sections. Height 0.158 mm., diameter 0.06 mm., height of sheath 0.06 mm., diameter of sheath 0.09 mm.

*Habitat.* Upon fronds of the brown kelps *Macrocystis pyrifera* and *Nereocystis luetkeana*, feeding on colonies of the bryozoan *Membranipora membranacea*. Monterey Bay, California, and vicinity. *Corambe* and *Corambella* may be found upon the same colonies, the two nearly related forms bearing a close resemblance to each other. The presence of the median, rounded, posterior notch in the notaeum of *C. pacifica* and the simple tapering rhinophores of *C. bolini* readily distinguish them, as do the characteristic markings of the notaeum.

## EXTENDED ANATOMICAL DESCRIPTION.

*Alimentary system.* The prominent, ciliated, fleshy lips lead into the short oral tube. A few simple pyriform glands, lateral to the pharyngeal bulb, are prolonged as slender ducts opening just outside the oral tube or partly within it.

The *pharyngeal bulb* is laterally compressed, moderate in size, bearing a prominent muscular crop above, closely united to the bulb below. The nearly straight radula sheath projects behind. The bulb is lined by a moderately thick cuticle modified at the mouth opening into a ridge-like thickening (pl. 32, fig. 8) which bounds the lower part of the opening and is continued ventrally for a short distance behind the aperture toward the rotella. A similar thickening in *Corambe sargassicola* led Bergh (1871) to describe the presence of mandibles in the genus, which statement he later modified (1892). Paired mandibles are certainly absent.

The *radula* is rather long and quite small, so that its structure is not readily made out in all its parts. In a mature specimen of average size (length about 10 mm.) its length is approximately 0.6 mm.

The teeth are borne in 40 to 60 closely set rows, the half rows not being exactly opposite but somewhat alternate, a condition which made an accurate count of their number quite difficult. The dental formula is 40-60 (5-6:1:0:1:6-5). The anterior exposed portion is less slightly grooved in the mid-line, the posterior part much more so. The rachis is very narrow and bare, no vestige of a median tooth being present.

The first lateral tooth is relatively large, laterally compressed, its base quadrangular in profile, prolonged at its upper hinder angle into a bluntly pointed process forming a sort of minor cusp behind the main one. Laterally the base bears a thin wing-like projection curving around the basal margin, as shown in figures 2 and 3 of plate 32. In some preparations this appears to divide the base unequally, giving a sort of bifid or trifid appearance. Usually, however, it resembles more a curved wing-like process from the lower sides. H. Fischer (1891) figures the base of the first lateral in *Corambe testudinaria* as bifid and broad, whereas *Corambe sargassicola*, according to Bergh, 1871, figure 8 of plate 12, seems to present a somewhat similar division in what he erroneously identified as a median tooth. He later (1892) corrected this interpretation.

In *Corambe pacifica* a condition similar to that here described is present though somewhat less pronounced.

From the anterior upper angle of the base arises a short strong hook curving backward, widest in front and bluntly pointed, its tip curved somewhat toward the midline of the radula. Upon its inner anterior margin is borne a series of some five to nine short pointed denticles, the largest above, the others decreasing progressively below until they become indistinguishable from the marginal thickening as the base is reached. Five outer laterals follow in closely set series. Each has a somewhat thickened base from which a short pointed anterior cusp arises. In general form these teeth resemble somewhat that of the first lateral. They diminish in size outwardly, the outermost ones sometimes being reduced to flattened basal rudiments. (Pl. 32, figs. 5, 6.)

In the older portions of the radula the cusps of the outer laterals may be worn away, broken, or absent. In sections through the radula sheath (pl. 32, fig. 7) their form is clearly outlined, in macerated radula preparations they may overlies each other or be otherwise distorted so that their forms and relations are by no means evident.

The vertical height of the first lateral from the posterior portion of the radula may reach 0.047 mm. from base to apex of the hook, the height of the hook alone 0.024 mm., the length of the base 0.27 mm. (Pl. 32, fig. 3.) These measurements are approximately one-half those of similar ones recorded by MacFarland and O'Donoghue (1929, p. 13) for *Corambe pacifica*. Such measurements have only a limited significance, however, since they vary throughout the radula and in radulae from specimens of different ages, but undoubtedly have a relative value.

*Salivary glands.* A pair of large, compact, sausage-shaped lateral salivary glands lie close behind the pharyngeal bulb and open widely into the bulb cavity above the radula. Above their entrance lie two additional salivary glands. These are small, compact, and nearly spherical. Each gives rise to a very short slender duct which penetrates the wall of the bulb immediately behind the crop, passes forward in the wall musculature, and opens into the bulb cavity above the radula and in front of the opening from the lateral salivary glands.

Cells of the larger salivary glands stain deeply. The nuclei have small granules; otherwise they are clear. The distal ends of the cells seemingly fray out into fibrils di-



rected toward the duct forming a network of deeply staining fibrils with clear interspaces. The cells of the smaller salivary glands are deeply staining, finely granular with regular contours, and there are no signs of vacuolations as in the larger glands.

The presence of what is here termed dorsal posterior salivary glands, as distinct from the larger dorso-lateral posterior glands, has not been noted by previous students of the Corambidae. But one pair is found in *Corambe pacifica* by MacFarland and O'Donoghue, and but one pair is described by H. Fischer for *C. testudinaria*.

*Glands of the foot.* Sole of the foot ciliated, the cells cuboidal, 0.0055 mm. in height, the cilia 0.00275 mm. long, the nuclei large, basal. Scattered along the epithelium are flask-shaped cells well below the surface with which it is connected by slender duct-like prolongations, these reaching to the surface between the cuboidal cells and filled with deeply staining secretion. The cell body is enveloped by a delicate membrane which is prolonged along the duct to the surface of the epithelium, evidently serving as a tube wall for this part.

On the dorsum of the foot and the sides of the body cilia are absent. Flask-like glands are abundant on the posterior dorsal foot surface; elsewhere they are rare.

Saccular labial glands open just below mouth orifice, 0.066 mm. in length, 0.027 mm. in maximum diameter. Cells large, finely granular, the nuclei clear basally with a large refringent nucleolus and very finely divided chromatin granules. Shape pyriform; similar ones above the mouth, with long ducts leading from the ovoid sacculi. Figure 8, plate 32, shows a section through the inner side of the lips, with ciliated cuboidal epithelium without.

The very thin-walled oesophagus passes backward from the postero-dorsal wall of the bulb, dilates in front of the nerve ganglion ring and again behind it, and opens into the stomach at the antero-dorsal surface of the visceral mass. Its wide cavity merges at once with the roomy hepatic cavity below so that no distinct boundary can be made out. The small cuboidal cells lining the gastric cavity, however, are ciliated throughout, while the hepatic cells are larger, cuboidal to columnar granular, and vacuolated. The visceral mass is made up of the thin-walled saccular liver and its more or less complete investment by the ovotestis. The mass fills the greater part of the body and shows indistinctly through its walls. Its central portion is incompletely divided peripherally into five lobes, two anterior, two median, and one posterior which is incompletely divided into two lateral portions. Incomplete septa of connective tissue extend from the notaeum to the foot, marking off these divisions.

Dorsally, a short distance behind the oesophageal opening into the stomach, the latter dilates somewhat, then narrows to a slender ciliated tube, the intestine, which diverges slightly to the right of the median plane of the body, curves downward and to the right of the roomy kidney, and passes directly backward to the anus, where it opens externally in the mid-line of the body.

*Excretory system.* The kidney resembles that described for *Corambe pacifica*. It is a thin-walled sac lying upon the mid-dorsal surface of the viscera, widening behind



into a more roomy reservoir just before reaching its very short external duct which opens close above the anal aperture, at its left side, in the mid-line of the body. The slender reno-pericardial duct unites with (opens into) the pericardial cavity on its right side by a short barrel-shaped or cylindrical syrinx lined with clear cuboidal cells bearing long cilia. Its opening into the pericardial cavity is directed outward and backward. The duct passes from the syrinx forward, close to the right ventral wall of the kidney, to its anterior portion where it opens into its lumen.

The external nephropore is directly above the anus.

*Nervous system.* The ovoid cerebral ganglia are united above the oesophagus by a short but distinct and broad commissure.

Close behind the cerebral ganglia are the pleural pair, distinctly separate from the cerebral and not fused into a cerebro-pleural mass as in most Nudibranchiata, but not in *Corambe pacifica* (MacFarland and O'Donoghue, 1929, pp. 15-17. pl. 2, figs. 8, 9; pl. 3, fig. 10). They are united to the cerebral ganglia by very short cerebro-pleural connectives, and with the pedal ganglia lateral to and below them by short pleuro-pedal connectives.

The large pedal ganglia are lateral and below the oesophagus and are united to the cerebral ganglia by quite short and wide cerebro-pedal connectives, and with each other below the oesophagus by the short pedal commissure, recognizable in serial sections.

From the antero-lateral end of the cerebral ganglia, the relatively long cerebro-buccal connectives pass forward and downward around the oesophagus to the spherical buccal ganglia, which lie in close contact with each other below the oesophagus at its emergence from the pharyngeal bulb. A pair of small gastro-oesophageal ganglia lie close behind and above the buccal ones.

The eyes are well below the integument, lateral to and above the hinder end of the pharyngeal bulb. The long optic nerve leads directly to a large optic ganglion which is nearly sessile upon the anterior face of the cerebral ganglia.

The statocysts lie laterally between the cerebral and pedal ganglia, receiving a very short nerve from the former. The spherical statocyst is about 0.015 mm. in diameter and contains a large number of minute elongated statoliths about 0.002 mm. long by 0.001 mm. in diameter.

The visceral loop is recognizable in sections. Its relations are essentially the same as given for *Corambe pacifica* (MacFarland and O'Donoghue, 1929).

The reproductive system of *Corambella bolini* seems to be similar to that described for *Corambe pacifica* save that the small spermatocyst there found does not appear to be present. The ovotestis is closely attached to the dorsal surface of the liver, overlapping it irregularly in front, laterally, and behind, and exhibiting closely set alveoli filled with ova and sperm in various stages of development. The hermaphroditic ampulla is large.

Family DORIDIDAE  
Subfamily GLOSSODORIDINAE

Genus *Cadlina* BERGH

*Cadlina* BERGH, 1879. Nudibr. Moll. North Pacific Ocean, Alaska, I. Proc. Philadelphia Acad. Nat. Sci., pp. 114-115. Genotype, *Doris repanda* Alder and Hancock, 1843, (= *Doris laevis* Linnaeus, 1767). MACFARLAND, 1906. Opisthobr. Moll. Monterey Bay, California. Bull. U.S. Bureau of Fisheries, vol. 25, p. 125. ODHNER, 1926. Die Opisthobranchien. Further Zool. Res. Swedish Antarctic Exp. 1901-1903, vol. 2, no. 1, pp. 55-64, pl. 2. THIELE, 1931. Handb. d. Syst. Weichtierk., vol. 1, pt. 2, p. 431.

The genus *Cadlina* was established by Bergh in 1879 for *Doris repanda* Alder and Hancock, and for a new species, *Cadlina pacifica* Bergh, from Alaskan waters. In Bergh's opinion it was useless to attempt to determine whether *D. repanda* of Alder and Hancock is the same as *D. laevis* Linnaeus or *D. obvelata* Müller, holding that the earlier descriptions without anatomical details are valueless and should be disregarded. It seems very probable, however, that *Doris repanda*, *Doris obvelata*, *Doris marginata*, and *Doris laevis* are all names applied to one and the same animal, which is *Cadlina*. *Doris laevis* Linnaeus, 1767, then is to be considered as genotype of *Cadlina* and is so accepted in the present paper.

On the Pacific coast of North America the genus is represented by the following four species: *C. pacifica* Bergh, 1879; *C. luteomarginata* MacFarland, new name; *C. flavomaculata* MacFarland, 1905; and the new species, *C. modesta* described below.

It may be noted that eight species of *Cadlina* have been found in the Southern Hemisphere, and nine in the northern, but the tropical regions are occupied by the closely related genera *Chromodoris* and *Glossodoris*. In the Pacific Ocean *Cadlina* reaches its southern limit in California.

*Cadlina luteomarginata* MacFarland, new name

Plate 23, figures 2-4; plate 29, figures 13, 13a; plate 33, figures 1-11

*Cadlina marginata* MACFARLAND, 1905. Proc. Biol. Soc. Washington, vol. 18, p. 43. Not *Doris marginata* Montagu, 1804. Trans. Linn. Soc. London, vol. 7, p. 79, pl. 7, fig. 7, (= *Cadlina laevis* Linnaeus, 1767). MACFARLAND, 1906. Opisthobr. Moll. Monterey Bay, California. Bull. U.S. Bureau of Fisheries, Washington, vol. 25, pp. 125-126, pl. 18, figs. 27-31; pl. 25, figs. 10-12. O'DONOGHUE, 1922. Nudibr. Moll. Vancouver Island Region. Trans. Roy. Can. Inst., Toronto, vol. 13, pp. 161-162, pl. 1, figs. 13-14. O'DONOGHUE, 1927. Nudibr. Laguna Beach, Calif. Journ. Entomol. and Zool., Pomona College, vol. 19, pp. 86-87, pl. 1, figs. 25-28.

This species was originally described in 1905 as *Cadlina marginata* MacFarland. Since that date it has been shown that *Doris marginata* Montagu, 1804, is identical with *Cadlina laevis* (Linnaeus, 1767), the genotype, and widely distributed in northern waters. The specific name *marginata* is, therefore, unavailable in *Cadlina*. The specific name of the Monterey form is consequently here altered to *luteomarginata*, thus preserving the reference to one of its very conspicuous color characteristics, the narrow

marginal band of yellow bordering the notaeum, the rhinophore sheaths, and the sides and hinder end of the foot.

*Body* elongate, elliptical, somewhat depressed, the notaeum firm, densely spiculate, everywhere covered with low spiculate tubercles. In alcohol the tips of these tubercles are flattened or even slightly concave, the largest more median ones reaching a basal diameter of 1.3 mm. in large specimens. Interspersed between these are smaller ones, and toward the margins the large ones are absent, the others decreasing more and more in size as the edge is approached, thus forming a well-marked marginal zone.

The *mantle margin* broadly overlaps the foot everywhere except behind, its undersurface showing a close network of radially elongate meshes owing to rows of spicules.

*Foot* narrow, nearly linear, spiculate, tapering behind to a thin blunt tip extending beyond the mantle, in front abruptly rounded, bilabiate, the upper labrum thin (very slightly notched, or no median notch), the lower one thicker.

*Head* small, inconspicuous, mouth a vertical slit, oral tentacles small, short, flattened, triangular, with a distinct external groove. When widely extended in life the tentacles may approach a cylindrical form, in fixed material the triangular form prevails.

*Eyes.* In an alcoholic specimen 3.4 mm. behind rhinophores, 1.4 mm. apart from each other, close to inner margin of dorsal retractor muscles of pharyngeal bulb.

*Rhinophores* small (pl. 29, fig. 13), the conical, perfoliate clavus inclined backward with 16 to 18 leaves, the cylindro-conical stalk erect, the whole organ completely retractile within a pocket, the thin margin of which bears very small, low tubercles.

*Branchial plumes* six, borne well back on the mid-dorsum, bipinnate spreading, completely retractile within the branchial cavity, the aperture of which is bordered by a low, thin, smooth or slightly tuberculate sheath.

*Reproductive openings* on the right side; the penis, behind the anterior foot margin, is a rounded papilla with central opening; close behind is a crescentic opening.

*Color.* (Pl. 23, figs. 2, 3, 4.) General body color pale yellow, almost white, the dorsal tubercles tipped with lemon yellow, each surrounded by a more or less well-defined ring of white, thus forming the centers of small polygonal areas into which the dorsum is divided. Mantle margin above, below, and lateral, and posterior borders of the foot edged with a narrow band of saffron yellow; tips of branchiae, rhinophores, and their sheaths lemon yellow. In alcohol the light yellow disappears in a short time and the animal becomes uniformly white.

*Labial armature* a broad yellow band, quadrangular below, narrowing laterally, and interrupted on the ventral side of the mouth tube. It is made up of minute, closely

set, narrow, simple, bifid hooks, the largest of which reach a height of 0.04 to 0.06 mm. The shaft of the element is erect, its outer third is bent sharply forward to form the hook, the tip of which is flat and blunt and forked into two sharp equal points, directed forward and outward. These rodlets are borne upon a homogeneous cuticular layer secreted by the columnar epithelium. (Pl. 33, fig. 7.)

At the posterior margin of the armature it passes below the surface into a sulcus or pocket, within which the hooks are formed as cuticular secretions of the epithelium, the youngest stages being found at the bottom of the groove.

The epithelium, at this point, is sharply reflexed upon itself as the upper wall of the sulcus returns to the surface, and is continued back in the mouth tube. Upon reaching the surface behind the sulcus, it develops a strong cuticle which lines the remainder of the oral tube, thinning away as the pharyngeal bulb is approached.

The tips of the rodlets first appear as cuticular formations upon the upper surfaces of the high columnar epithelium cells, or rhabdoblasts, at the bottom of the sulcus. By the formation of new layers of chitin, the rodlets progressively increase in length, and when the opening of the sulcus is reached they have attained their mature form and height. Continuous basal layers of chitin are now formed beneath the rodlets, increasing the thickness of the armature to about twice the height of the rodlets and uniting them in a continuous plate.

At the outer anterior margin of the armature the rodlets are broken off or worn away by usage and the basal chitin alone covers the outer lip, becoming reduced to a minimal layer as the lip boundary is reached.

The general features of this development of the labial armature are essentially the same as those described by MacFarland (1918) for the palatal spines of *Dolabella agassizii*, and have been found for the other species of *Cadlina*, *Glossodoris*, and *Chromodoris* given further on in the present account.

The *radula* is broad, its length 4.9 mm., its maximum width 3.9 mm. in large specimens, the dental formula approximating 90-114 (47-58:1-47-58). The rachis is very narrow (pl. 33, figs. 1, 2), bearing a single series of compressed median teeth, erect and broadly hooked, the cusp squarish with a slight median groove upon its anterior surface, its posterior edge divided into four to six large, usually blunt denticles; the lateral teeth are in 47 to 58 rows, the youngest 10 to 12 immature in the sheath of the radula.

The first pleural tooth (pl. 33, fig. 2) is strongly hooked with two to four strong denticles on its inner margin and six to seven smaller ones on the outer. The succeeding pleurae of much the same shape are progressively more compressed, the cusp longer and more pointed, the denticles increasing to 12 or 14 and limited to the outer margin alone. (Pl. 33, fig. 4.) Beyond the middle of the half row the outer pleurae become more erect, less curved, diminish in size (pl. 33, fig. 3), being finally reduced to flattened slightly concave plates, the outermost two or three frequently rudimentary.

*Reproductive system.* The ovotestis closely covers the lower anterior and lateral surfaces of the liver. The hermaphroditic duct arising from it passes forward to the an-

terior genital complex in a short course and dilates into the saccular hermaphroditic ampulla, which forms a few close loops upon the inner flattened face of the elliptical complex, narrows abruptly, and opens into its lumen, giving off, in so doing, the vas deferens. (Pl. 33, fig. 9.) A large specimen collected by G. D. Hanna near Cape Mendocino was used for dissections.

The male duct is made up of a proximal, wide, glandular segment some six to eight times longer than the short and narrow distal portion. The prostatic segment is lined by high columnar cells packed distally with fine secretion granules; the short, muscular, distal segment has a narrow lumen lined with low cuboidal cells bearing an armature of minute, closely set, chitinous hooks. The outer opening of the vas deferens into the short preputium is upon a small papilla-like elevation, scarcely large enough to be called a glans penis.

The lining of the vas deferens is eversible and, when extended, protrudes as a delicate tube covered with the rows of minute hooks which continues, at its tip, with the interior lining. This muscular armed segment is proportionately much shorter than that found in *Cadlina flavomaculata* and *C. modesta*, often found in the same tide pools near Monterey Bay.

The vestibular opening of the vagina (pl. 33, fig. 9) is close behind that of the preputium. It leads into a long tapering tube terminating in the large, thin-walled, spherical spermatheca. The low cuboidal epithelium of the vagina is closely ridged lengthwise, and bears a relatively thick cuticular surface, continuing inward to the short duct of the spermatheca.

A short distance, 1.2 mm. inward from the external opening of the vagina, a slender duct is given off, leading to the somewhat spherical spermatocyst which lies close to the spermatheca and of slightly more than one-half the diameter of that organ, its exposed face being about 1.4 mm.

The spermatheca is filled with spermatozoa and cellular debris as usual, while the spermatocyst contains only mature sperm.

Close to its entrance into the spermatocyst, its duct gives off the short uterine duct which leads almost directly into the cavity of the gland complex from which the short and wide oviduct leads to the external opening in the genital cloaca, close behind and below the openings of the vas deferens and the vagina.

*Spicules and glands.* The dorsum is covered with rounded, low, cylindrical papillae, mushroom-like in form, with flattened surface, up to 1.0 mm. in diameter of varying sizes. Each is filled with a large number of spicules radiating slightly at the outer end of the papilla.

Between the papillae the integument is reinforced by interlacing bands of spicules forming a wide meshed network. As the margin is approached, the papillae become much smaller and closer together. (Pl. 33, figs. 10, 11.)

*Dimensions.* Alcoholic specimen. Length over all 38.7 mm., width 16.8 mm., height 8 mm.

Living specimen. Length 45 mm., breadth 22 mm., height 8 to 10 mm.



Tubercles on dorsum widest, 1.4 mm. at base. Dorsum bounded all around by a zone of small tubercles 1 mm. wide.

*Habitat.* This well marked species has been frequently taken in rocky tide pools of Monterey Bay and the adjacent coast northward and southward. It has been recorded from the Vancouver Island region (O'Donoghue, 1922, 1924), from La Jolla, California (Cockerell, 1905, 1908), and Laguna (O'Donoghue, 1927), and has been taken by Dr. G. Dallas Hanna near Cape Mendocino, and by the writer at Crescent City, Newport Bay, Laguna, and La Jolla. Its known range at present is from Vancouver Island, British Columbia, to the San Diego region, California.

### *Cadlina flavomaculata* MacFarland

Plate 23, figure 1; plate 29, figure 12; plate 33, figures 12-21

*Cadlina flavomaculata* MACFARLAND. 1905. Prelim. Account Dorididae of Monterey Bay. Proc. Biol. Soc. Washington, vol. 18, p. 43. MACFARLAND. 1906. Opisthobr. Moll. Monterey Bay, California. Bull. U.S. Bureau of Fisheries, vol. 25, pp. 126-128, pl. 19, figs. 32-37; pl. 21, fig. 110; pl. 25, fig. 9. O'DONOGHUE, 1922. Trans. Roy. Can. Inst., Toronto, vol. 14, pt. 1, pp. 154-155, pl. 6, figs. 16-18. O'DONOGHUE, 1924. Trans. Roy. Can. Inst., Toronto, vol. 15, pt. 1, p. 23. O'DONOGHUE, 1927. Journ. Entomol. and Zool., Pomona College, vol. 19, pp. 85-86, pl. 1, figs. 20-24.

*Body* elongate, almost linear, depressed, bluntly rounded at the ends, slightly less so behind than in front; the strongly spiculate mantle widely overlapping the foot, its dorsal surface everywhere bearing small, low, rounded tubercles or nodules occasionally inconspicuous, the under surface of the wide margin smooth in life.

*Foot* very narrow, linear, bluntly pointed behind, in front abruptly rounded, bilabiate, its lower lip fleshy, rather thick, the upper one thinner. The foot is strongly spiculate except in its marginal areas.

*Head* small, fitting into a depression in the ventral surface of the mantle, the mouth triangular, broadest below, its margin somewhat inflated, densely glandular, the tentacles short, flattened, bluntly auriform or triangular, their external margin grooved.

*Rhinophores* rather large, erect, slightly divergent, the clavus long, perfoliate with 10 to 12 leaves, deeply retractile within low sheaths, the margins of which are thin and slightly nodular; branchial plumes far back on dorsum, small, usually ten in number, simply pinnate, occasionally in part bipinnate, completely retractile within a dorsal cavity bordered by a low, thin, slightly nodular margin. (Pl. 29, fig. 12.)

*Color.* (Pl. 23, fig. 1.) General color light cream to yellow. On each side of the mantle is a longitudinal series of seven to ten small, lemon-yellow, rounded spots, the first one of them just outside of and behind the rhinophores, the posterior one outside of and usually behind the branchiae. One specimen taken in 1925 showed beneath the mantle margin on either side a row of lemon-yellow spots similar to those on the dorsum.



The clavus of the rhinophore is light colored with a translucent tip; the leaves are brown to very dark brown giving the whole a very dark and striking appearance.

In alcohol the dark color of the rhinophores usually persists, the dorso-lateral rows of lemon-yellow spots become white, but are usually clearly distinguishable, owing to the presence beneath each spot of a large, spherical, integumentary gland.

*Labial glands* in a thick mass, surround the external oral openings in front of the labial armature. The individual unicellular elements lie mainly below the epithelium with which they are connected by slender prolongations extending up to the surface between the epithelial cells. The secretion is of a mucous nature as indicated by the staining.

*Labial armature* a broad, light yellow, convex band, quadrangular below, triangular at the sides, and interrupted above, its elements small, closely set, chitinous hooks, bifid at the distal end, .0165 mm. in height. (Pl. 33, fig. 16.) These hooks or rodlets are formed within a deep sulcus marking the posterior boundary of the band (pl. 33, fig. 17), behind which the simple cuticular lining of the oral tube continues back into the pharyngeal bulb.

*Radula* (pl. 33, figs. 12-15) small, the functional portion nearly flat, a median groove appearing in the sheath. Teeth in some 77 rows, the dental formula 77 (23·1·23), the rachis narrow, bearing a single row of relatively massive median teeth, the base triangular, the nearly horizontal hook divided into four to six long, nearly equal, blunt denticles, these extending the full length of the hook.

The pleural teeth typically 23 in number, the innermost wide with a stout cusp bearing two or three large denticles upon its inner margin, and four to seven upon the outer; the second and following laterals have no denticles upon the inner face of the hook, the outer denticles increasing in number.

Toward the middle of the row the tooth becomes more and more compressed, the denticles increasing to 12 to 15 and becoming larger and more prominent, the whole tooth taking on a saw-like form; laterally the outermost three or four decrease somewhat in size but not so much as in the two other species of *Cadlina*, the apical cusp remaining longer than the denticles.

*Reproductive system.* The ovotestis covers the dorso-anterior and antero-lateral faces of the liver. From its lobules their ducts unite forming the hermaphroditic duct which passes forward and swells into the long ampulla (pl. 33, fig. 18, *h. a.*) on the right side of the anterior genital complex.

As it narrows and passes into the latter, it gives off the very long (about .320 mm., 0.16 mm. in diameter) thick glandular or prostatic segment of the vas deferens (pl. 33, fig. 18, *p. v. d.*), which winds in convoluted loopings forward along the inner flattened face of the complex.

Near the anterior surface, it suddenly narrows to less than one-half its diameter, its glandular epithelial lining is replaced by a low cuboidal lining with a thick outer

layer of circular and longitudinal muscle fibers and connective tissue about .150 mm. long, 0.015 mm. in diameter.

This muscular segment of the vas deferens (pl. 33, fig. 18, *m. v. d.*) is looped in a number of intricate turns upon the anterior face of the anterior genital complex which are then encircled and suspended in a large nearly transverse loop, dilating into the preputium as it approaches the body wall. At the base of the preputium, at its widest point, the vas deferens opens upon the summit of a small papilla, so small that it can scarcely be called a glans penis, its basal diameter 0.21 mm., its length 0.135 mm.

The vas deferens, at the opening and leading back to about the point *x* in figure 18 of plate 33, is lined by minute, closely set, thorn-like, cuticular hooks borne by the low epithelial cells, the armed segment is 1.12 mm. long. This epithelial layer rests upon a thin layer of connective tissue and muscle, and is surrounded by a blood channel separating it from the main muscular wall of the vas deferens. By increasing blood pressure within this space, the lining armature may be everted beyond the gland aperture in copulation and may be found in this phase in favorably fixed material, the armature forming an external layer, continuous at its tip with the internal one with the distended blood space between the two, more or less clearly shown in sections.

The hooks are about 0.004 mm. in height, with basal widths of 0.002 mm., and are arranged approximately in six somewhat irregular rows. In the retracted condition they nearly fill the lumen of the vas deferens.

The walls of the preputium may also be everted so that the aperture of the vas deferens lies upon the center of a rounded papilla, the central portion of which represents the glans, the remainder the everted wall of the preputium. From this center the everted armature of the vas deferens projects to a greater or less extent, forming an extension of the central canal for the passage of the sperm in copulation and coming in intimate contact with the chitinous lining of the vagina.

Close behind the male aperture is that of the short female vestibule containing the openings of the vagina and the oviduct. The vagina wall is at first thick and strongly muscular, its cuboidal epithelium bearing a thick layer of chitin and thrown into low longitudinal folds which lead inward to the vaginal duct. (Pl. 33, figs. 18, 19.)

The vagina narrows abruptly and becomes the vaginal duct, which is terminated by the pear-shaped spermatheca. Midway of this long duct arises the duct of the spermatocyst. Close to this sac issues the uterine duct which disappears within. (Pl. 33, fig. 19.)

*Spicules and glands.* The mantle is densely crowded with spicules, the foot less so. They are also present in the sides of the body, the sheaths of the rhinophores and gills, the axis of the rhinophores, and to a slight extent in the rhinophore leaves. They are mainly elongate, spindle-shaped, straight or slightly bent. They are hollow, thin-walled structures, either with smooth or slightly nodular surfaces.

The largest spicules measured, reached a length of 0.955 mm. and a maximum diameter of 0.045 mm. In addition to the straight spicules, spherical masses of calcite also occur, either very small spherules or larger aggregations of two or more, ranging

in size from 0.002 to 0.042 mm. in diameter, doubly refractive in polarized light. The foot is strongly spiculate.

The mantle integument is thickly set with small and large multinuclear alveolar glands. These are so closely set that the general external epithelium is obscure. Glands are found at the bases of the gills.

*Dimensions.* Living specimens range from 20 mm. in length, 8 to 10 mm. in width, and 4 mm. in height to smaller ones 15 mm. in length, and 6 mm. in width.

Alcoholic specimens range from 24 mm. in length and 11 mm. in width to smaller ones 13 mm. in length and 5 mm. in width; the latter were used for dissections.

*Habitat.* Not rare. Found in rocky tide pools along the coast of western North America from San Diego to Puget Sound. Taken by the writer at La Jolla, Corona del Mar, Crescent City, and various intermediate points.

Recorded by O'Donoghue (1922, 1924) from the Vancouver region.

### *Cadlina modesta* MacFarland, new species

Plate 30, figures 14, 15; plate 33, figures 22-31

*Body* elongate elliptical, depressed, firm, slightly broader in the anterior half than in the posterior. Mantle margin broad, extending widely beyond the narrow foot margin except at the posterior end, covered with thickly set, low, rounded tubercles, large and small intermingled. The ventral surface of mantle shows a white network of radially directed lines made up of rows of spicules showing through the integument.

*Foot* narrow, rounded and bilabiate in front, with a small median notch, everywhere overlapped by the broad mantle margin except behind, where the short slightly rounded tip of the tail protrudes when crawling freely.

The *head* is rather broad, with a median groove, rounded in front. Laterally it is prolonged into two triangular lobe-like oral tentacles, the outer edges of which are grooved lengthwise.

*Rhinophores* retractile within low, nearly smooth-edged sheaths, the clavus slightly dilated, perfoliate with 10 to 12 leaves, the stalk, clavus, and leaves strengthened with slender spicules.

*Branchiae* of 10 to 12 simply pinnate, slightly spreading plumes situated well back on the median line of the mantle, retractile within a cavity bordered by a low thin margin bearing minute tubercles.

The *eyes* are conspicuous.

External *reproductive openings* are 2.6 mm. back of the anterior foot margin on the right side. The penis opening is in a conspicuous pore, except when the margins are everted forming a ridge. The other openings are at the base close together.

*Color.* The mantle is uniformly cream color, occasionally yellow with a tint of orange. A continuous irregular series of small lemon-yellow spots, 16 to 20 or more, are scattered toward the margin of the notaeum and extend around in front of the rhinophores and posteriorly beyond and behind the branchiae toward the median line. Rhinophores light, seldom dusky, branchial plumes light. The much larger number of small lemon-yellow spots are near the notaeum border; their irregular arrangement and extent, and the colorless rhinophores readily distinguish this new species in life from *Cadlina flavomaculata* with which it otherwise agrees in general external features and with which it might be confused. Its internal anatomy, however, shows many distinguishing characters.

The lips and oral tube immediately in front of the labial aperture are thickly beset with tubular mucous glands. The *labial armature* encircling the lumen is made up of three light-brown cuticular plates, a triangular one on either side, and a basal quadrangular one below, the three closely united below, the laterals but slightly separated above.

The plates are composed of a homogeneous cuticular layer upon its basal epithelium, upon which is borne a myriad of closely set bifid rodlets (pl. 33, figs. 27, 28) slightly curved toward the outer end, forming erect hooks, the longest, about 0.016 mm. in length, near the anterior margin of the plate and decreasing backward progressively, the smallest at the bottom of a sulcus which limits the hinder margin of the plate. Here the rodlet tips make their appearance as cuticular differentiations upon the summits of columnar epithelial rhabdoblats and are increased in height by basal accretions of chitin from the tops of the cells, as described previously in other *Cadlina* species.

The basal cuticula uniting the individual rodlets makes its appearance opposite the summit of the groove and increases in thickness progressively toward the anterior margin of the armature plate. Behind the sulcus a smooth cuticle extends backward into the pharyngeal bulb and unites with its general cuticular lining.

*Radula* (pl. 33, figs. 22, 26) small, 0.90 mm. long by 0.45 in width, quadrangular, its anterior functional part flattened, without a median furrow which appears posteriorly at the entrance of the radula sac. Radula formula of mature specimens ranges from 70 (21·1·21) to 94 (24·1·24), the latter in a specimen of 24 mm. total length.

Median tooth (pl. 33, fig. 22) of a squarish form, the base widened behind, narrower in front, its cusp broad, square, slightly emarginate in the antero-median border, bearing four long, equal, blunt denticles. The median teeth vary but slightly in size throughout the radula, the total length and the width of the hinder basal margin measuring about 0.015 mm., the width of the cusp 0.012 mm., and the length of the denticles 0.011 mm.

First lateral tooth broad (pl. 33, fig. 22), its base extending obliquely outward, the large thickened cusp rising from its inner face, two strong denticles on the inner side of the cusp and four or five smaller ones on the outer (pl. 33, fig. 22); second lateral with a strong cusp on its inner margin, no denticles upon the inner face, and five upon the outer.

The lateral teeth beyond the second become progressively higher and more compressed, the cusp becomes larger and apical, and the outer face bears an increasing number of lateral denticles which decrease in size, the tooth taking on a high, slender, saw-like form (pl. 33, figs. 23, 25), with 12 to 15 small pointed denticles. The outermost laterals are reduced to very slender, slightly curved structures (pl. 33, fig. 26), almost needle-like, with but few (about ten) small denticles. The maximum vertical height of the laterals is about 0.06 mm. The first two lateral teeth on either side, and the included median tooth, are all strikingly broader than the remaining laterals, causing the median portion of the radula to stand out distinctly from the remainder in this regard.

*Reproductive system.* (Pl. 33, fig. 29.) The ovotestis covers the anterior face of the liver in a thick layer, extending backward laterally and below for a variable distance. Ova and sperm are produced in separate alveoli of the lobules, the ductules of which unite to form a short hermaphroditic duct passing forward to the anterior plano-convex genital complex and dilating into the closely looped ampulla upon its lower inner face. Here it narrows, gives off the vas deferens, and enters the gland mass.

The vas deferens is made up of a long, proximal, glandular segment irregularly looped upon the upper inner face of the complex, and a long, distal, more slender muscular segment, coiled in a large spiral of some four turns with an average diameter of 0.195 mm.

Distally it dilates into the conical preputium containing the short papilla-like glans penis. In the outer part, 1.35 mm. in length, the vas deferens is lined by a heavy cuticle bearing a multitude of small thorn-like hooks upon a low cuboidal epithelium. Surrounding this inner layer is a muscular sheath of circular and longitudinal fibers separated from the thicker outer muscular wall by a clearly defined blood space.

The vagina is a short cylindrical tube, .045 mm. long by .03 mm. in diameter, opening externally into the genital vestibule close behind the penial aperture. Its proximal portion leads into the vaginal duct, at first narrow but soon increasing to a proximal dilatation 0.37 mm. in diameter and 1.2 mm. in length. Its wall is strong and muscular, the fibers mainly circular in direction. The low cuboidal epithelial lining bears a very thick cuticle folded with the epithelium into closely set longitudinal ridges (pl. 33, fig. 31). At its proximal end the vaginal duct narrows and receives the duct of the nearly spherical spermatheca, about 0.45 mm. in diameter.

From the duct of the spermatheca, close to its entrance into the vaginal duct, arises the duct of the thin-walled spermatocyst, an ellipsoid sac 0.10 mm. in diameter by 0.59 mm. in length, distended with mature spermatozoa. Close to the entrance of this duct issues the slender uterine duct, approximately 1.5 mm. long and opening into the cavity of the adnexed gland complex.

This relationship of the seminal vesicles to the vagina and the uterine duct is termed the semiserial arrangement by Odhner and seems to be characteristic of the California species of *Cadlina* so far as studied in this regard.



*Integumentary glands and spicules.* The mantle sides and foot are all very densely spiculate, the spicules mostly elongate, spindle-shaped, and hollow, either straight or slightly bent. The largest spicules reach a length of 0.3 mm. and a diameter of 0.27 mm. The outer refringent wall of the spicules approximates 0.0013 to 0.0015 mm.

The cuboidal epithelium of the mantle surface is closely beset with the ducts of small saccular mucous glands, some quite small, others extending deep down in the integument.

*Dimensions.* Living specimens average in dorsal length 10 to 30 mm., width 4 to 13.3 mm., height 3 to 6 mm.

A large alcoholic specimen measures 19 mm. in length by 8.5 mm. in width. Another is 10.8 mm. in length by 5.8 mm. in width, 3 mm. in height; foot 8.7 mm. in length, 2 mm. wide at anterior end.

*Habitat.* The earliest recorded living specimen was collected June 18, 1908, from the Large Tide Pool, Point Pinos. It is a small white dorid, in general aspect like *Cadlina flavomaculata* and of similar size. Labial tentacles similar, possibly slightly larger and more slender. Color pale yellow, dorsal surface flecked with small, round, lemon-yellow spots of the same color as the dorsal lateral series of *C. flavomaculata*, but these are scattered irregularly around the outer zone. The central dorsal area is free from the yellow. Rhinophores are of the same color as the body, the left inclines to a light brown. Branchial plumes simple pinnate.

Collections were made most frequently from the Large Tide Pool at Point Pinos and from the rocky open pools of Point Cabrillo, the author collecting. This was done over a period of years, 1908 to 1941. One specimen received from Miss Myrtle Johnson from La Jolla, No. 102, was labeled: "White dorid, yellow spots, *Cadlina*."

Two specimens were photographed by the author. The larger is used on plate 30, figures 14, 15, dorsal and ventral views. This specimen has dorsal measurements of 20 mm. in length and 10 mm. in width. The ventral length overall is 19 mm., width 6 mm. The contracted foot is 17 mm. long, the width of margin beyond foot, 3 mm.

#### A COMPARATIVE SUMMARY OF PACIFIC COAST CADLINAE.

The three species of *Cadlina* here mentioned are readily distinguished from other dorids of Monterey Bay and from each other by their form and striking coloration. Their sizes vary but slightly. They have in common a tuberculated dorsum which is densely spiculate.

The general body color ranges from pale cream to light and deeper yellow. The lemon-yellow spots on the dorsum of each species are distributed, however, in quite a different pattern. The striking dark rhinophore plates of *C. flavomaculata*, with its constant line of lemon-yellow spots on either side of the dorsum and the pale gill, mark it definitely from *C. lutocomarginata*. This is the only one of the three to have the lemon-yellow lines which occur on the upper and lower edges of the mantle as well as on the



lateral and posterior edges of the foot. Each tubercle of the dorsum being capped with lemon yellow as well as the gill plumes and rhinophore tips, makes this nudibranch a very gay spot in the tide pool. *Cadlina modesta* has a slightly wider dorsum which is a pale-yellow color and has a continuous irregular series of small lemon-yellow spots, 16-20 or more, scattered toward the margin of the notaeum. The gill plumes and rhinophores are quite pale.

In *C. luteomarginata* the radula is quite large, 4.9 mm. long by 3.9 mm. wide. The radula formula is 90-114 (47-58·1-47-58); the median tooth bears four nearly equal blunt denticles with no median cusp; the first lateral has two to three denticles on the inner and six to seven on the outer face of the hook, the outer denticles of the successive pleural teeth increasing to 12, the outermost teeth being reduced to irregular jagged plates. The radula of *C. flavomaculata* has a formula of 77 (23·1-23), the median tooth bearing four to six long, nearly equal, blunt denticles, the first lateral with two to three inner and four to seven outer ones. The outer denticles increase to 12-15 and distally the whole tooth takes the form of an irregular saw.

The radula of *C. modesta* is quite small, being 0.90 mm. in length by 0.45 mm. in width. Its formula is 70-94 (21-24·1-21-24).

The median tooth has a square shape, the base widened behind, the cusp broad and square, bearing four long equal, blunt denticles.

The first lateral has a large thickened cusp, bearing on its inner side two strong denticles with four to five smaller ones on the outer face. The second lateral has a strong cusp but no denticles on the inner face, five on the outer face. The succeeding laterals become progressively higher and more compressed, the cusp larger, the outer face bearing an increasing number of denticles which decrease in size, the tooth becoming saw-like in form.

The outermost laterals are reduced to very slender slightly curved structures, needle-like with but a few small denticles.

Thus the median tooth is quite similar in the three species, but there is quite a marked variation in the laterals, most especially in the outermost ones. The new species *C. modesta* has in general a similarity in the shape of the teeth with those of *C. flavomaculata*, but the manner in which the denticles are borne on the main cusp is quite different.

There are slight differences in the shape of the labial armature hooks, and some marked differences in the general arrangement of the reproductive parts.

*Cadlina pacifica* Bergh, 1879, taken at Unalaska and the Shumagin Islands, has not yet been taken south of Alaska. Its color is described as "bluish-white" and "bluish" in life, and uniformly yellow in alcohol. The radula formula is 85 (33·1-33), the median tooth has a distinct median cusp with three to four lateral denticles, the first lateral tooth bears five to six denticles on the inner face of its hook and six to seven on the outside, and the denticles on the other laterals increase to 18 to 20.

Baba (1949) listed two species of *Cadlina*, *C. japonica* Baba, and *C. sagamiensis* Baba, neither of which appears to be closely related to the California species.

## RADULAE OF PACIFIC CADLINAS

Species	Rows and Dental Formulae	Median Tooth	First Pleural	Outer Pleural	Outermost	Color
<i>Cadlina pacifica</i> Bergh	67-85 (33•1•33)	Three to four denticles on each side of a median cusp.	Five to six denticles on inner, six to seven denticles on outer face.	No inner denticles. They increase 18-22 on outer face.	Two to three pleural usually without denticles.	Bluish white.
<i>Cadlina luteomarginata</i> MacFarland	90-114 (47-58•1•47-58)	Four to six nearly equal denticles. No median cusp.	Two to three denticles on the inside, six to seven on outer margin of cusp.	No inner denticles. Increase to 12 on the outer face.	Irregular jagged plates.	Pale yellow to white, lemon lines and spots.
<i>Cadlina flavomaculata</i> MacFarland	77 (23•1•23)	Four to six long equal denticles. No median cusp.	Two to three denticles on the inner, four to seven on the outer margin of cusp.	No inner denticles. Increase to 15 on outer face. Tooth becomes saw-like.	Become more slender and saw-like, denticles small.	Cream, yellow marginal spots.
<i>Cadlina modesta</i> MacFarland, new species	70-94 (21•24•1•21-24)	Four equal blunt denticles. No median cusp.	Broad, large cusp bearing two denticles on the inner, four to five on the outer margin.	No inner denticles. Outer ones increase to 12-15. Tooth much compressed and saw-like.	Very slender and needle-like. Few rudimentary cusps.	Pale yellow, lemon-yellow spots in an irregular band on edge of dorsum.
<i>Cadlina japonica</i> Baba	53 (50-60•1•60-50) to 102 (110-115•1•110-115)	Akkeshi, Sagami Bay Toba Kii				
<i>Cadlina sagamiensis</i> Baba	112 (110-115•1•110-115)	Sagami Bay				

Genus *Glossodoris* EHRENBERG

*Glossodoris* EHRENBERG, 1831. *Symbolae Physicae*, p. 93. BERGH, 1877. *Kritische Untersuchungen der Ehrenberg'schen Doriden*. *Jahrb. der deutsch. Malakozool. Gesell.*, Jahrg. 4, p. 53.

*Glossodoris macfarlandi* (Cockerell)

Plate 22, figures 1-5; plate 34, figures 1-11

*Chromodoris macfarlandi* COCKERELL, 1901. *Coloration of Nudibranchiata (Chromodoris)*. *Nature*, vol. 65, pp. 79-80. COCKERELL, 1902. *Three new species of Chromodoris*. *Nautilus*, vol. 16, pp. 19-21.

*Glossodoris macfarlandi* (Cockerell), O'DONOGHUE, 1927. *Notes on a Collection of Nudibranchs from Laguna Beach, California*. *Journ. Entomol. and Zool., Pomona College*, vol. 19, pp. 89-90, pl. 2, figs. 33-37.

*Body form* (pl. 22, figs. 1, 2, 3) somewhat squarish in cross section, elongate linear. Mantle rounded in front and behind, its lateral margins widely projecting beyond the sides, the thin edge undulating. Anterior end prolonged into a rounded velum somewhat wider than the mantle behind, concealing the head region and the foot except at the posterior end.

*Labial tentacles* short, lobe-like, tapering, obscurely grooved on the outer margin. Mouth a short, longitudinal slit.

*Foot* narrower than mantle, its anterior margin widest, truncate, bilabiate, the upper labrum very slightly emarginate, not notched, the foot tapering to a bluntly pointed tail which extends beyond the mantle.

*Rhinophores* (pl. 22, fig. 4) well separated, the stalk stout, short, tapering, the clavus perfoliate with about 16-20 plates in front united with a narrow depressed median ridge, behind joining to a similar one not so depressed.

*Eyes* not conspicuous on the surface, but when the dorsum is removed they show as two minute black spots on the dorsal lateral surface of the bulb.

*Branchial plumes* borne in a nearly complete circle well back upon the dorsum into which they are completely retractile within a pocket bounded by a thin, low, smooth-edged sheath. Gills 11 in number, stalk thickened, bearing 16 plates, simple pinnate, slightly flaring when fully extended. Posterior two at times bifid or even arising as a basal branch from the one just anterior. Longest gill plume 4.5 mm. high. When the gill plumes are completely extended, the bases seem to be united in a low incomplete ring within the collar. (Pl. 22, figs. 1, 5.)

*External reproductive openings* on the right side a short distance posterior of the rhinophore base. Alcoholic specimens show the margins tumid, inflated, small papillae. Tip of glans showing, behind it a second smaller papilla, possibly at the margin of the genital ampulla.

The series of hemispherical *glandular nodules* borne on the ventral surface of the hinder end of the mantle, so conspicuous in *Chromodoris californiensis*, seem to be absent in this species.

*Labial armature* exposed, light-brown band behind, deepening to darker at outer margin. Broader at the bottom and sides, narrowing upward, apparently interrupted above and on the ventral side; cleft at top. Total length about 2 mm., 1 mm. wide at base. Length from front to entrance of follicle approximately 0.65 mm.

During the study of a horizontal series, the following notes were made: Rodlets curved forward in distal half; proximal half borne obliquely on high epithelium. Bases of the rodlets united by homogeneous cuticle which appears close in front of the follicular-groove aperture and increases in thickness forward, becoming the smooth thick cuticle of the tube beyond the boundary of the rodlets. (Pl. 34, figs. 6, 7.)

Near the front margin the height of the rodlet approximately .036 mm. Basal cuticle .018 mm. in thickness; epithelium height .024 mm. The height of the rodlets is actually the length of a straight line from base to tip, not ventral height. Tips of rodlets are simple points, not bifurcate.

The features of the development of the labial armature have been previously described for *Cadlina luteomarginata*. This was done in detail for *Dolabella agassizii* MacFarland, 1918.

*Radula* (pl. 34, figs. 1-5) dissection notes. A broad follicle gland, lying in the mid-line between the rhinophore in front and the eyes, was found on the bulb. Another similar gland was found dorsally upon the hinder part of the bulb, its anterior end about at the level of the eyes, its hinder end overlapping the loop of the intestine.

The median plate of the radula is clearly a median tooth and not a spurious plate as termed by Bergh in other species such as *Chromodoris dalli*. (Pl. 34, figs. 10, 11.) As seen from above, it presents the form of an equilateral triangle, its length being but slightly broader than its greatest width; posterior margin ranging from 0.0124 mm. to 0.0137 mm. in the same radula. The upper surface is raised into a low but distinct spine nearly as wide as the flattened base upon which it rests. Its anterior tip is pointed, and the whole corresponds in position to the basal part of the adjacent laterals. Its posterior end thins away to a vaguely jagged border as do the laterals.

The first lateral has an oblique broad base upon the anterior end of which is borne a broad hook, coarsely denticulate upon both its inner and outer margins. Upon the median sides of this hook is a smaller more irregular hook, in places appearing as a basal group of two or three nearly equal denticulations. The first laterals may vary somewhat in size in the same row as is shown in plate 34, figure 1, or they may be quite uniform.

The second lateral bears a single hook which is denticulate upon its outer margin only; the base is expanded in a wing-like plate on the inner margin overlapped by the first tooth. Cusp strong, prominent, borne on the outer border of the base; denticulate. Third and fourth teeth similar.

The fifth lateral becomes more compressed, the hook more prominent and stronger, denticulate on outer margin. (Pl. 34, fig. 3.) The succeeding laterals become progressively more and more compressed and elevated, the hook becoming more prominent and strongly curved, its denticles sharply pointed, being transformed from a stout hook to a flat blade-like element terminated at the top by a sharp point, larger than the series of five denticles, 20-30 on the outer margin, below it.

Near the outermost of the laterals the teeth become smaller and the denticles are limited to the uppermost end, the terminal point becomes much less clearly marked, and the whole tip of the tooth may take on a somewhat spoon-shaped outline, being slightly hollowed on its inner face, or the whole may be reduced to a low flattened rudiment.

Greatest (vertical) height of laterals from middle of row 0.090 mm., length of base 0.070 mm.

The formula for the radula is 62 (50-47·1-50-47)62.

*Color.* (Pl. 22, figs. 1-5.) In life the general ground color is a deep violet (a mixture of rose madder and permanent blue), lighter in the mid-dorsal area and the sole of the foot, deepening toward the margin of the mantle and on the sides of the body, becoming deeper in color above the area of the dorsal margin.

The rhinophore stalks and those of the gill plumes are a pale clear violet. The plates of the rhinophores are very dark, extending to the lowest plates of the clavus, a very deep red-violet with a reflection of blue on the edges. The rhinophores are the most striking feature of the dorsum. The stalks of the gill plumes deepen in color on the outer third to a deep violet garnet in tone. This color occurs on the tips, gill plates, and the outer central face of the stalks, shading away into the lighter color below. (Pl. 22, figs. 4, 5.)

A narrow median stripe of cadmium orange (golden yellow) passes backward from just behind the velar margin, between the rhinophores, and terminates at the mid-frontal margin of the branchial sheath. Another similar narrow line of cadmium orange begins just behind each rhinophore sheath and passes backward along the dorso-lateral area, encircling the branchial pocket, uniting behind with its fellow, occasionally with a widened triangular point. Along the mid-dorsal area of the tail a narrow band of cadmium orange, shorter or longer, is present, or there may be a series of small spots.

A narrow band of cadmium orange edges the whole of the mantle, accompanied by a submarginal band of pure white of nearly equal width. This white band gradates into the deep violet of the ground color. The ventral side of the mantle is encircled on the edge by a white line but no yellow.

One specimen was observed to have several scattered small spots of yellow on the mantle behind the gill and the posterior arch, formed by the union of the lateral bands posterior to the gill. These are prolonged backward in a broad point, the tip of which was encircled by the above spots.

In 4 per cent formalin the violet color disappears, but faint traces of the orange persist; in alcohol little trace of color is left.

*Reproductive system.* The dorsal surface of the liver is covered by the large gland of the ovotestis. The adnexed genital mass, 1.5 mm. by 3 mm., is a flattened ellipsoid. The hermaphroditic duct arises from the ovotestis by small ductules which unite and dilate on the inner posterior face of the mass, its superior end passing beneath its closely looped proximal part of the spermatic duct, dividing into that duct and the oviduct, the latter passing at once into the compact gland complex. The first and major part of the vas deferens is thick, approximately 1 mm. in diameter, and is closely looped upon the dorsal margin of the mass, forming two loops upon the spermatheca; it then narrows somewhat, becomes more muscular, forms loops free from close contact, and dilates into the preputium which opens into the genital vestibule.

Immediately below and behind the penis is the slender vagina which leads by an S-shaped loop of the more slender vaginal duct to the spermatheca, a thin-walled spherical sac about 1.2 mm. in diameter upon the upper posterior border of the adnexed genital mass. Very close to the entrance of the vaginal duct is given off the short duct leading to the sausage-shaped spermatocyst, 1.4 mm. long by 0.5 mm. in diameter. Closely connected with this duct, leading from the vaginal duct, is the very short uterine duct entering the mass. Opening into the ventral side of the genital vestibule is the rather wide duct of a large saccular *vestibular gland*. (Pl. 34, fig. 8.)

*Dimensions.* Living specimens vary in length up to 35 mm., width 8-10 mm., height 6.5 mm. Preserved material is much more variable in measurements depending upon the degree of contraction.

In alcohol a well extended specimen measures 14.1 mm. in length, 6-8 mm. in width, 3.6 mm. in height. The foot length is 12.5 mm., its width at the anterior end 2.5 mm., its middle area 1.6 mm., the tail length beyond the mantle 2.8 mm.

The following detailed measurements were made from the living specimen sent from the Kerckhoff Marine Laboratory:

- |   |   |
|---|---|
| 1. Length 32 mm.  | 7. Ventral anterior width of velum 12 mm.     |
| 2. Width 8 mm.  | 8. Rhinophore to anterior mantle margin 6 mm. |
| 3. Height at heart 6.3 mm.                              | 9. Rhinophore to gill margin 17 mm.           |
| 4. Length of foot 27 mm.                                | 10. Mantle margin to tip of tail 2 mm.        |
| 5. Anterior width of foot 7 mm.                         | 11. Height of rhinophore 4 mm.                |
| 6. Anterior margin foot to anterior mantle margin 5 mm. |   |

*Habitat.* This species is comparatively rare in Monterey Bay. The first specimen recorded was dredged by S.S. Berry off Moss Landing, 1906, in 12 fathoms. During the summers of 1907, 1908, 1909, five specimens were collected in the Large Tide Pool at Light House Point by Weymouth, Heath, and Snyder, professors from the Hopkins Marine Station. Two were reported in 1941, both taken off Point Pinos, one by Dr. Bolin, the other by Dr. Robertson and which was kept in his aquarium for two weeks. The species is more abundant from San Pedro southward. The first material received by the writer was sent by T.D.A. Cockerell in 1902 from the La Jolla region. Two fine specimens were collected in Newport Bay in June, 1948, by Dr. George E. MacGinitie



and sent by air mail. From these the colored figures were made and the detailed measurements taken.

### Genus *Chromodoris* ALDER AND HANCOCK

*Chromodoris* ALDER and HANCOCK. 1855. Monog. British Nudibranch Mollusca, pt. 7, p. 17. [Odhner, (Proc. Malac. Soc. London, vol. 32, pt. 6, 1957, pp. 250-253) discussed the "*Chromodoris* contra *Glossodoris* a systematic-nomenclatorial controversy" in some detail and gave an excellent list of references. In a postscript he indicated that he had received the specimen upon which Ehrenberg based *Glossodoris* and that an examination of the radula would be reported upon as soon as possible. Until this is done the editors of this report do not feel justified in altering the arrangement of these two generic names from the way Dr. MacFarland left them in 1948.]

### *Chromodoris californiensis* BERGH

Plate 24, figures 1-3; plate 34, figures 12-23

*Chromodoris californiensis* BERGH. 1879. Nudibr. Gasterop. Moll. North Pacific Ocean - - Alaska. 1, II. Proc. Acad. Nat. Sci. Philadelphia, vol. 31, pt. 1, pp. 112-114; vol. 32, pt. 2, 1880, pl. 14, figs. 5-15. (Pl. 14, figs. 5-15, bears the name "*Chr. calensis* B." which seems to have been the name intended by Bergh, but changed in the manuscript by the printer under the impression that it was an abbreviation of *californiensis*, *vide* Bergh, in errata list, pt. 2, p. 125.) BERGH. 1894. Bull. Mus. Comp. Zool. Harvard, vol. 25, no. 10, pp. 181-182, pl. 7, figs. 23-28. Gulf of California, 24° 11' N. Lat., 109° 55' W. Long., off La Paz, 10 fms.

*Glossodoris californiensis* (Bergh), O'DONOGHUE. 1926. List Nudibr. Moll. Pacific Coast North America. Trans. Roy. Can. Inst., Toronto, vol. 15, pt. 2, p. 211. O'DONOGHUE. 1927. Notes on Nudibr. from Laguna Beach, California. Journ. Entomol. Zool., Pomona College, vol. 19, pp. 90-91, pl. 2, figs. 38-42.

Bergh's description is based upon a specimen collected by Dall at low tide in the harbor of Santa Catalina Island, California, in January, 1874. The color as given by Dall was "mazarin-blue with golden spots, changing to greenish blue in the alcohol, which it continues to color for a long time, and after several changes for fresh spirit".

Length of the rather contracted animal 12.0 mm. and 6.0 mm. broad and high. Color in alcohol uniformly greenish blue. On the dorsum were several yellowish white round spots, a millimeter in diameter, in front chiefly in the median line, on the rest in two longitudinal series, outside of which were scattered some similar spots, and on each side of the body was a line of four or five of the same kind. A brighter fine line seemed to border the margin of the mantle edge and that of the foot. Rhinophores green-blue, branchiae dark green-blue.

Mantle edge narrow, wider over head and tail. On the under side of the mantle above the tail were six semiglobular nodules, each 1.0 mm. in diameter. Rhinophore clavus perfoliate with about 20 leaves. Branchial plumes nine.

Labial armature of elongated plates each bearing a thick, recurved, hooked point, rarely bifid. Radula teeth in 82 rows with 98 teeth in each half row; no median tooth, a

single series of flattened, rudimentary, pointed plates (O'Donoghue). The lateral teeth are hooked, the hook bifurcate at the point, the outer and posterior branch shorter, denticulate, the denticulations continued down the external margin of the hook. Innermost teeth lower and with few denticles, the more external teeth larger with six to eight denticles (eight to ten, O'Donoghue), the outermost teeth more irregular and modified in form.

The species indicated as *Chromodoris universitatis* by Cockerell in 1901, and more fully described in 1902, is undoubtedly the same as the species of Bergh, as held by Eliot (1905) and by O'Donoghue (1927).

Cockerell's description is as follows: "Length about 67 mm., rather narrow, mantle less ample than in *C. mcfarlandi*, not expanded at the sides; rhinophores and branchiae wholly retractile; rhinophores stout, with numerous transverse lamellae; branchiae of about 12 large simply pinnate plumes, several more or less branched, and so bipinnate at the ends; oral tentacles just concealed by mantle; hind end of mantle gibbous; foot projecting 20 mm. behind end of mantle; breadth of sole when crawling  $8\frac{1}{2}$  mm.

"Color rich dark ultramarine blue, the edge of the mantle and the edge of the foot bright cobalt blue; rhinophores very dark blue; mantle with two longitudinal series of oblong very bright orange spots, about seven in a series; five round orange spots on the anterior part of the mantle, in front of the rhinophores; under surface of posterior lobe of mantle with a series of eight round white spots, the hindmost four large, the others smaller and rather faint; sides of foot with a series of over ten round or oval orange spots; branchiae very dark blue, speckled with orange within; sole deep blue.

"The splendid blue pigment of this animal is dissolved out after death, even in sea-water; but very fast in formalin, producing a blue liquid which is turned pink by hydrochloric acid, but is not affected by alkalis, except that strong alkalis rapidly bleach it. Curiously, the orange spots of the animal seen through the blue solution, appear red, though in reality their color is not altered."

#### LIVING SPECIMEN FROM NEWPORT BAY.

*Body* elongate, somewhat compressed, the lateral mantle margins narrow, in front widened and dilated into a broad undulating velum concealing the head. Dorsum sloping upward from rhinophores to the highest point in the cardiac region. The drop from here to the gill opening is marked and abrupt. Behind, the margin is rounded, projecting.

*Tail* broad, elongate, limaciform, bluntly rounded at the tip, projecting far beyond the notaeum border. (Pl. 24, figs. 1, 2, 3.)

*Rhinophores* widely separated, the clavus dilated, perfoliate with about 20 leaves; a narrow ridge up both the front and back, the same height as the edges of the plates. The stalks are short and stout, the whole retractile within low smooth-edged sheaths.

*Tentacles* short, conical, directed forward and outward, the mouth region small, the opening a short, longitudinal slit.

*Foot* elongate narrow, its anterior end dilated, rounded, the margin bilabiate behind, with slightly undulating margin, prolonged beyond the notaeum as a long rounded tail. Foot margin is 1 mm. beyond side of body in anterior tail region.

Posterior mantle margin overlapping the anterior end of the foot, its ventral surface bearing several (five to nine) prominent, hemispherical, glandular elevations, each with a central pore-like opening.

*Gills* 9 to 12 borne far back on mid-dorsum, retractile within a cavity, the margin of which is low, thin, and smooth. Branchial plumes usually simply pinnate, 12 to 15 plates, but occasionally one or two may be bipinnate near the tip, the anal opening a low papilla near the center of the branchial circle, the minute renal pore near its base.

*Eyes* are well back from the bases of the rhinophores, 3.5 mm., very small and black, conspicuous in the center of a light oval area, slightly depressed.

*External reproductive openings* on a prominent papilla on the right side well up under the mantle margin, about 10.5 mm. posterior to the anterior margin of the foot.

*Labial armature* (pl. 34, figs. 21, 22) a pale-yellow band incompletely encircling the mouth opening, of nearly uniform width, 1.6 mm., interrupted below and less so above. It is made up of an enormous number of closely packed rodlets, the free ends of which are curved outward as strong pointed tips, not forked. These rodlets are borne upon a basal layer of cuticle which continues beyond the limit of the armature as the cuticular covering of the lips. The posterior margin of the armature is occupied by a sulcus into which the rodlets are continued and in which they are formed, as described for *Cadlina luteomarginata* and *Glossodoris macfarlandi*, preceding. The basal cuticular layer uniting the rodlets is formed at and in front of the sulcus and it increases in thickness forwards.

Rodlet height up to 0.039 mm., its thickness 0.009 to 0.012 mm., the horizontal length of the pointed tip as measured in surface view ranges from 0.01 mm. to 0.014 mm. (Pl. 34, fig. 22.)

The *pharyngeal bulb*, separated from the anterior reproductive organs and the liver, is 5.5 mm. long, 2.8 mm. wide, and 3.0 mm. high. It is nearly cylindrical, the radula sheath projecting at the hinder end as a keel-like projection, its equator curved and clearly marked, 1.8 mm. high.

*Salivary glands* white, slender, strap-shaped, emerge from loop of central nervous system above the small paired buccal ganglia and course outward and downward, ending in the connective tissue behind the bulb, between it and the anterior genital mass and the anterior end of the liver. Right gland is approximately 3.4 mm. long, left gland approximately 2 mm. long.

*Radula* broad, deeply grooved, the teeth in 73 rows, with up to 114 teeth in each half row and no trace of a rudimentary median plate in a specimen of 13.3 mm. length after preservation, the dental formula thus being 73 (114·0·114).

Bergh (1879) gives 82 (98·0·98) for the preserved type specimen of 12 mm. length, and (1894), 49 (62·0·62) for a 7 mm. specimen; Cockerell and Eliot (1905) give 108 (100·0·100) for a preserved specimen of 28.5 mm., while O'Donoghue (1927) gives a formula of 90·92 (132·128·R·P·128·132) for a specimen of unstated length. It is to be remembered, however, that preserved material may vary enormously in dimensions, depending upon the methods of anesthesia and fixation used.

Bergh (1879, 1894) found no median plates, "rachidial thickenings, spurious teeth" in his material; Cockerell and Eliot (1905) describe none, nor have we been able to find any. O'Donoghue (1927), however, figures a row of flattened median plates and describes them as quite conspicuous. Since these rachidial plates are more or less vestigial in this species, it is quite possible that they may be present or absent in different specimens.

The first lateral tooth compressed, hooked, with strong pointed cusps, the median one slightly larger and in advance of the others. In the next laterals the cusps are reduced to two, the innermost disappearing, the outermost is behind the main median one and shows traces of fine denticulations on its outer margin which become more conspicuous further outward. The two hooks become united below, the union finally resulting in a compressed plate divided at its summit into two curved cusps.

Upon the margin of the inner posterior one of these are borne a series of five to ten small pointed denticles, the uppermost of which may be well out upon the hinder margin of the cusp, the others extending down to the base of the plate. The base is narrow, slightly thickened, and prolonged backward as a thin plate. (Pl. 34, figs. 15, 16.) The outermost laterals (pl. 34, fig. 17) become reduced to flattened, scale-like plates, the denticles larger and more irregular, the two cusps becoming indistinguishable from the irregular margin.

#### EXTENDED DESCRIPTION.

*Reproductive system.* (Pl. 34, fig. 23.) The hermaphroditic duct, arising from the ovotestis, passes into an elongated large ampulla. This is crescentic in form, lying on the ventral surface of the adnexed genital mass in a groove between the nidamental surface parts entering close to its emergence as the vas deferens.

It dilates suddenly into the long glandular segment which forms a close complicated series of loops upon the posterior surface of the spermatheca. At this point the duct becomes slender and muscular, forming a number of loops as it reaches and enters the proximal end of the preputium passing to the vestibule.

The glandular portion has a diameter of 0.5 mm., the muscular segment 0.3 mm. The glandular segment is approximately ten times the length of the muscular.

Close to its fusion with the gland wall the very short oviduct emerges, passes directly outward, receiving the very short duct of the elongate sausage-shaped (2.2 mm. long) *spermatocyst* and joins the straight duct of the *spermatheca* which, as the vagina, leads directly outward to the external opening just below and behind that of the penis.

*Glans* short, tapering, blunt, unarmed, borne at the base of the preputial sac.

*Spermatheca* spherical, diameter 3.4 mm., nearly concealed beneath the loops of the vas deferens. It is filled with immature sperm; hermaphroditic ampulla also filled with sperm.

Adnexed genital mass nearly spherical, somewhat flattened, 5.8 mm. by 5.8 mm. by 4.2 mm. Convolutions of the vas deferens, vagina, spermatheca, and spermatocyst form a mass median to the nidamental gland complex and nearly equals it in size.

The *preputium* is 1.2 mm. long by .8 mm. maximum diameter and tapers directly into the slender vas deferens across the dorso-anterior face of the complex.

*Vestibular gland.* A thin, delicate, vestibular gland spreads over the outer face of the anterior genital complex, its fine slightly branched tubules enmeshed in the connective tissue at the surface and accompanying it inward between the penis, vas deferens, and vagina for varying distances. Owing to the intimate relations with the fine connective tissue framework, the complete tubules of the gland are very difficult to isolate. They appear to converge to a single main duct opening into the vestibule close to the orifice of the oviduct.

*Color.* The color of the mantle, the sides, and the dorsal surface of the tail are a deep, rich, ultramarine blue, toned with red-violet.

A light marine-blue margin, 1 mm. wide, forms a slight ridge as a boundary of the back. In side view this light-blue band seems to be divided lengthwise in the center by a very narrow dark line which may be the actual thin edge. Opposite the rhinophores the notum margin widens and curves downward and outward, being expanded into the thin undulating velar margin. This margin is bordered by a broader band of light blue, while the ventral surface has a wide area of the light color.

The ventral surface of the foot, its anterior margin, and the dorsal edge are all the lighter marine blue. This tone is found on the stalks of both the gills and the rhinophores. An intermarginal zone shades very gradually (and in an irregular outline) from the light color into the deeper blue of the sides and the velum.

Posteriorly, lateral to the gills, the light marginal line of the dorsum is entirely absent, and the surface of the notum in this region is a strikingly darker color, to ultramarine blue is added carmine to give a deeper rich color. This same depth of color is found on the plates of both the rhinophores and gill stalks, as well as on the lobular tips of the anterior tentacles. Beneath this posterior velar area are large hemispherical *glandular elevations*, light marine blue in color. The presence of the deeper color above runs coincident with these glands.

Two longitudinal lines of elongated-orange spots occur on the notum between the rhinophores and the gill, continuing posterior to it. Two large median spots are close behind the rhinophores. In front, on the velum, are seven or more spots of variable size, irregularly arranged in a semicircle about the margin. On each side of the body a single row of elongated spots occurs, continuing beyond the notum edge as a



median row of four or five on the dorsal surface of the tail. Small spots of yellow are found on the inner faces of the gill plumes.

In preserved material the general color disappears, and the yellow spots may survive as traces, or in some cases, as well-marked outlines.

*Hemispherical glands.* These lie beneath the margin of the mantle, five or more in number, forming an arc about midway of the distance between the free margin of the mantle and the union of the latter with the body wall. They are readily seen in alcoholic material. (Pl. 34, fig. 19.)

On the underside of the frontal velum, slightly in front of the level of the rhinophores, are two slightly elevated whitish nodules on the right side and one on the left in the same position. These resemble the larger ones under the hinder mantle margin.

*Dimensions.* This species, comparatively, is quite large and most striking in color. Miss Guernsey reported it to be the largest nudibranch collected at Laguna Beach Laboratory.

*Living specimens.* Cockerell and Eliot, 1906, 28.5 mm. long, 12 mm. wide, 15.5 mm. high; Guernsey, 1912, 55 mm. long.

Two large specimens collected in Newport Bay by George E. MacGinitie and sent to Pacific Grove were used for paintings. (1) Larger, 60 mm. long, 6.5 mm. wide, 9 mm. high at the heart, 55 mm. foot length, 5 mm. foot width anterior end, 4 mm. foot in center, 11 mm. length of tail, 5 mm. anterior end of foot to veil margin, 9 mm. width of veil, 5.5 mm. height of side from foot to dorsal lateral edge, 5.5 rhinophore height, 5 mm. gill plume height. (2) Smaller, 45 to 50 mm. long, 6 mm. wide, 7.5 mm. high.

The above two in alcohol measured: (1) 45 mm. long, 10 mm. wide, 12 mm. high; (2) 29 mm. long, 6.5 mm. wide, 7 mm. high.

Bergh's specimen, alcoholic, 1879, 12 mm. long, 6 mm. wide, 6 mm. high; Bergh's specimen, alcoholic, 1894, 7 mm. long, 2.75 mm. wide, 3 mm. high.

*Habitat.* Monterey Bay, California, to the Gulf of California. Taken at Catalina Island harbor, at low water by Dall in 1874, the type specimen; also at San Diego and Monterey bays (Dall). Also taken at San Diego Bay by Orcutt, 1885. Gulf of California off La Paz, 10 fathoms, April 30, 1888, "*Albatross*."

Taken at San Pedro, Laguna, La Jolla, by Cockerell, Eliot, and Guernsey, 1901, 1905, 1912.

Taken by MacFarland at Monterey Bay, Carmel Bay, and La Jolla, 1909, 1946; by Weymouth, Monterey Bay, 1908.

Many specimens taken by G. E. and N. MacGinitie in Newport Bay from Corona del Mar, Balboa piling, Arch Rock, 1932-1949; Punta Peñasco, Sonora, Mexico, December, 1947.

Four specimens by Stillman Berry, September, 1949, Punta Peñasco, Sonora, Mexico.



***Chromodoris porterae* Cockerell**

Plate 24, figures 4, 5; plate 34, figures 24-31

*Chromodoris porterae* COCKERELL, 1902. Nautilus, vol. 16, pp. 19-21. MACFARLAND, 1905. Prelim. Account Dorididae Monterey Bay, California. Proc. Biol. Soc. Washington, vol. 15, pp. 44-45. MACFARLAND, 1906. Opisthobr. Moll. Monterey Bay and Vicinity. Bull. U.S. Bureau of Fisheries, Washington, vol. 25, pp. 129-130, pl. 26, figs. 13-14. GUERNSEY, 1912. Some Mollusca of Laguna Beach. First Ann. Rep. Laguna Marine Laboratory, pp. 74-75, fig. 39 B. O'DONOGHUE, 1926. List Nudibr. Mollusca recorded from Pacific Coast North America. Trans. Roy. Can. Inst., Toronto, vol. 15, pt. 2, p. 212. O'DONOGHUE, 1927. Notes on a Collection of Nudibranchs from Laguna Beach, California. Journ. Entomol. Zool., Pomona College, vol. 19, pp. 91-92.

The slightly modified description of Cockerell (1902) is as follows (also given on page 129 of MacFarland, 1906):

Length about 11 mm., form of *Chromodoris universitatis* (= *Chromodoris californiensis*) but uniformly much smaller, and quite different in markings. Deep ultramarine blue, including the whole of the foot; mantle with two rather broad longitudinal stripes of bright orange, not united posteriorly, and ending anteriorly at the rhinophores, but anterior to the rhinophores is a transverse orange stripe; as if a continuation of the lateral stripe; a median light-blue line extending from between the rhinophores to the branchiae, margins of the mantle very narrowly pure white; foot wholly without marks; rhinophores and branchiae entirely retractile. Branchial plumes 11 in a circle, simply pinnate, entirely of the color of the mantle. After death, a number of conical white papillae (about 9 on each side) appear beneath the hind part of the mantle. After death the blue dissolves out, and the body becomes a pale greenish blue, with the dorsal stripe very white; the orange bands as in life.

*Habitat.* In rocky tide pools at low tide, La Jolla, Cal., early in August, rather common. (Wilmatte Porter Cockerell.)"

In the summer of 1894 a single individual of *Chromodoris* was taken at Light-house Point, Monterey Bay. Colored drawings of plate 26, figures 13, 14, and the following descriptive notes were made largely from it. (MacFarland, 1906.)

*Body* narrow, elongate, linear, depressed, smooth, about equally rounded in front and behind, the mantle margin rather narrow laterally and behind, in front broad, the broadly tapering tail projecting well beyond the mantle margin and concealing several large sub-velar hemispherical glandular enlargements.

*Foot* deeply notched in front, narrow, extending into a long, narrow, pointed tail.

*Anterior tentacles* are small, tapering, divergent.

*Rhinophores* stout, the clavus perfoliate with 12 to 14 leaves, retractile within low, smooth margined sheaths. *Branchial plumes* 9 to 11.

*Anal opening* in center; *eyes* inconspicuous.

*Reproductive openings* on the right side high under the mantle edge, 4 to 5 mm. posterior of the anterior foot margin.

*Mandibles.* The pharyngeal bulb completely everted in a specimen 9 mm. long, measured 1.3 mm. in length by 7 mm. in width. A piece of mouth tissue, adhering to the radula was examined. The labial rodlets found on this, from the armature, appear wide, arranged in rows. From a teased-out portion these were separated. They are 0.019 to 0.022 mm. in length by .005 mm. wide. Figure 29 on plate 34 shows a rodlet dilated at the tip, paw-like, bearing four or five curved denticles, all pointed forward.

Small bifid labial rodlets are common in the genus. However, this seems to be the first case of multifid rodlets yet observed; they are much larger than those of the bifid type. (Pl. 34, figs. 26, 29.)

*Radula.* From a fragment in glycerine, extremely small and delicate, a drawing was made of the outer ends of a group of teeth. Apparently bifid at the tip, the hinder margin bears relatively long pointed denticles, the whole being exceedingly small. The makeup of the rows and the number of teeth were not determinable from this fragment. (Pl. 34, fig. 24.)

Later, from an alcoholic specimen 5.3 mm. long, 3 mm. wide, 2.5 mm. high, an imperfect radula mount was made and the following facts gleaned. The total length is 0.16 mm.; there are 40 rows of teeth plus six to eight immature ones in the radula sac. There are 28 in the older part which are very difficult to count.

As clearly as can be made out there is no median plate. The teeth are lamellate, bifid at the summits, their bases long, much compressed, hooks denticulate, six to seven long denticles on the outer ones. (Pl. 34, figs. 25, 27, 28.)

*Reproductive system.* The *vestibular gland* (pl. 34, fig. 30) is made up of interlacing tubules originating from the branching of a single duct leading into the genital vestibule close to the external opening of the oviduct. The gland covers two-thirds to three-fourths of the adnexed genital mass and fits closely the surface of the nidamental complex from which, however, it is readily separated by dissecting needles. It opens by a single duct into what seems to continue into the gland mass as a broad tube.

The *nidamental-albumen gland* appears to be a continuous closely wound tube. It encircles the spermatheca, as seen in an inner surface view. The hermaphroditic duct was not identified. Fragments of the vas deferens proximal glandular part were dissected out. (Pl. 34, fig. 31.)

*Color.* The general body color is more subdued than the ultramarine blue of *C. californiensis*. Permanent blue, with carmine, was used in the colored figures; a little black was added to darken. (Pl. 24, figs. 4, 5.)

Two broad longitudinal stripes, yellow to orange, follow the mantle margin, entirely or incompletely united behind the branchiae, terminating just outside the bases of the rhinophores. A transverse arc of the orange color encircles the widened velum margin. These stripes are about 1 mm. from the edge and merge with the blue of the body in a slightly irregular line.

A median pale-blue line extends from between the rhinophores to the branchiae, continuing behind, limited by the orange arc; the same pale-blue color is in a median line on the tail and the edge of the foot which otherwise is the deep blue of the body. This lighter blue is found on the stalks of the gill and rhinophores, while the plates of these are a very deep rich blue.

The mantle margin is narrowly edged with white shades into a pale-blue sub-marginal area, this merging into the deeper blue of the sides.

*Caudal glands.* Under caudal veil prominent, distended mantle glands some 15 in number, the largest extending well beyond the mantle margin as flask-shaped or slightly tapering translucent papillae, the largest near the mid-line behind, the smaller farthest forward at the beginning of the caudal velum, well in front of the contracted branchial opening.

Immediately behind the level of the rhinophores, on the lateral margin of the mantle, appear two cylindro-conical, blunt, glandular papillae projecting outward from the dorsal surface close to the margin of the mantle. They reach a height of 0.4 to 0.5 mm. and are similar in every respect to those of the posterior velar region. Another specimen had 18-20 posterior glands well forward on the sides. These are the only ones so far found in this species which are located in any other position than beneath the posterior velum. *Chromodoris porterae* is the smallest of the three species described.

*Dimensions.* Living specimen, Monterey Bay. Large specimen taken by H. Heath, 1908, length 20.5 mm.

MacFarland specimen, 1894, 22 mm. long. Rhinophores 1.5 mm. high with 12 to 14 leaves, gill plumes 1 mm. high, expanded gill 1.5 mm. Seven specimens averaged in length 13.7 mm., width 3.2 mm., height 3.1 mm. The largest specimen, taken in Monterey Bay, was 28.2 mm. in length, the smallest, taken in Newport Bay, 5.3 mm. long, 3 mm. wide, 2.5 mm. high.

*Habitat.* Taken at La Jolla and San Diego by Cockerell, 1901; at Laguna Beach by Guernsey, 1911; at Monterey by MacFarland, 1894, Snyder, 1907, and Heath, 1908.

#### Subfamily ALDISINAE

#### Genus *Rostanga* BERGH

#### *Rostanga pulchra* MacFarland

Plate 25, figure 7; plate 29, figures 7-10; plate 35, figures 1-16

*Rostanga pulchra* MACFARLAND, 1905. Proc. Biol. Soc. Washington, vol. 18, pp. 40-41. MACFARLAND, 1906. Bull. U.S. Bureau of Fisheries, vol. 25, pp. 119-122, pl. 24, fig. 8; pl. 18, figs. 18-21. ELIOT, 1907. Proc. Malacol. Soc. London, vol. 7, no. 6, pp. 339-341. (*R. pulchra* a synonym of *R. muscula* Abraham.) GUERNSEY, 1912. Some Mollusca of Laguna Beach. First

Annual Report Laguna Marine Laboratory, p. 77, fig. 38 A. O'DONOGHUE, 1922. Notes on Nudibr. Mollusca from Vancouver Island Region, III. Trans. Roy. Can. Inst., Toronto, vol. 14, no. 1, pp. 152-154, pl. 5, figs. 12-15. O'DONOGHUE, 1927. Journ. Entomol. and Zool., Pomona College, vol. 19, pp. 82-83, pl. 1, figs. 10-12. DE LAUBENFELS, 1927. Red Sponges of Monterey Peninsula, Calif. Ann. Mag. Nat. Hist., ser. 9, vol. 19, pp. 258-266.

*Rostanga arbutus* (Angas, 1864), BABA, 1949. Opisthobranchia of Sagami Bay, p. 149, pl. 23, figs. 83-85, text figure 74.

Length 2-3 cm. *Back* covered everywhere with closely set villous papillae strengthened by divergent spicules extending from base to apex. General integument also rich in spicules. Rhinophore-sheaths and branchial cavity papillate similarly to the general dorsum. Branchial plumes six to nine, bipinnate, arranged in a complete circle round the anus. Oral tentacles digitiform. Coloration of body more or less variable in different specimens. Usually the general color is vivid orange-yellow, but the back is sprinkled with black dots which may collect together into blackish mottles of varying sizes. Branchial plumes are the same color as the body. Stalks of rhinophores orange-yellow, the clavus dark brown, the tip yellow.

*Labial plates* paired, band-like, formed of simple rods. The representative radula formula is 60(50-60·0·50-60). First lateral hamate, bearing a series of 20-30 denticles on the inner edge; the succeeding laterals also hamate, but without denticles; the outermost laterals slender, each split at the tip.

*Body* elliptical, somewhat depressed, the ends of the body equally rounded, the mouth margin ample, covering the whole body except the tip of the tail when crawling.

*Notaeum* covered everywhere with small hispid papillae, in height ranging up to 0.42 mm., in diameter to 0.08 mm., each one strengthened by a number of divergent nearly straight spicules extending from base to apex, the central area of the apex sunken and surrounded by the higher margin which is elevated at intervals by the spicule tips into pointed projections. (Pl. 35, figs. 14, 15.)

*Foot* abruptly rounded in front, its sides nearly parallel, more tapering behind to a short bluntly pointed tip. Anterior margin of foot deeply bilabiate, the upper lip notched in the median line. Oral tentacles digitiform, long, and slender.

*Rhinophores* (pl. 29, figs. 7, 8) short, stout, the stalk stout and conical, prolonged above the clavus as a blunt cylindrical process, nearly one-fourth the length of the whole organ. Clavus perfoliate, bearing altogether from twenty to twenty-four nearly vertical leaves, ten to twelve on each side. The leaves are rather thick and triangular, with the apex directed downward, increasing in size regularly from anterior to posterior.

Rhinophore tip directed obliquely forward, the rest of the organ nearly vertical. Rhinophores completely retractile into pockets, the low margins of which bear a series of papillae similar to those of the general notaeum surface.

*Branchial plumes* ten to twelve, erect, separate, nearly equal in size, arranged in a circle upon the posterior mid-dorsum, and completely retractile within a low sheath,

the margin of which bears papillae similar to those of the general notaeum. Anal opening at the summit of a low papilla in the center of the circle of branchiae, the minute renal opening at its right and slightly in front. (Pl. 29, fig. 9.) Alveolar gland at the base of each gill plume.

*Eyes* inconspicuous.

External *reproductive openings* on the right side 3 mm. posterior to the anterior foot margin.

General *ground color* (pl. 25, fig. 7) bright red, varying from light yellow-red to deep scarlet, the back sprinkled everywhere with minute brown and black spots between the papillae. The extent of these dark sprinklings is highly variable, in some specimens being very small, in others more abundant, often grouped in small patches, deepening the general color of the animal to a red-brown. The color of the sides and the ventral surfaces of foot, mantle, stalks of the rhinophores, and gills are a pale scarlet, with no brown markings. The rhinophore plates are a deep scarlet. In alcohol the red color is quickly lost, the more permanent brown becoming very conspicuous upon the light yellow-white of the preserved animal.

*Labial armature.* Mouth opening an inverted-T, the lips convex, covered with a thick colorless cuticle. (Pl. 35, figs. 11, 12.) Labial armature a crescentic band, 0.24 mm. long by 0.072 mm. wide, of flattened rodlets on either side of the opening. The elements of this armature are arranged in five or six closely overlapping rows, the most anterior ones blunt, flattened, but slightly elevated and curving forward. The rodlets of the succeeding rows decrease in size, becoming shortened and more pointed.

The largest rodlets reach a length of 0.015 mm. with a basal diameter of 0.0055 mm. The hindermost rodlets occupy a shallow groove bounding the band, and are much lower than the more exposed anterior ones. (Pl. 35, figs. 9, 10.) These rodlets are less numerous than those described for *Rostanga coccinea* and *Rostanga perspicillata* by Bergh.

The ducts of the anterior *salivary glands* join the mouth tube close in front of the armature.

*Radula* broad, colorless, the median groove deep. Dental formula, 68-80 (81-0-81), the rachis naked, first pleural tooth thick and stout, its base short and broad, its hook heavy, slightly curved, with eight to eleven small denticles upon its inner margin. (Pl. 35, fig. 1. a.)

The succeeding ten pleural teeth have a large, broad, and strong base expanded laterally and outwardly and overlapping the adjacent tooth. The hook or cusp of each is strong and thick. From about the twelfth lateral outward the hook lengthens and becomes more slender and less curved, passing over rather rapidly into long, slender elements, each with a small compressed wing-like base and a long, slender, slightly curved hook bearing distally from one to six very long denticles upon its inner margin. (Pl. 35, figs. 4, 7, 8.)



These denticles are borne in the outer third of the hook and, increasing slightly in length from within outward, reach nearly to the tip of the tooth and give it the appearance of being divided. The outer teeth are very slender and flexible, thus giving to this portion of the radula a brush-like appearance. Longest laterals approximately 0.137 mm. long, the base 0.005 mm. wide, the shaft 0.003 mm., tapering toward the tip. (Pl. 35, fig. 8.)

*Reproductive system.* The glans penis unarmed, the vas deferens short, the prostate gland large, thin-walled; spermatheca spherical, very large, making up nearly two-thirds the bulk of the anterior genital mass.

Close behind the penis the vagina passes inward beneath the elliptical spermatocyst to the large spherical spermatheca, opening into it on its median face. Close beside its entrance a duct emerges, passes directly to the spermatocyst giving off, close to its entrance, the uterine duct which passes at once into the gland complex. (Pl. 35, fig. 16.)

*Dimensions.* Living, largest taken, length 18 mm.; width 10 mm.; height 5.5 mm.; the average size usually found, however, is from 8-12 mm. in length; 4-6 mm. in width. Alcoholic specimens range from 3-12 mm. long, by 2-8 mm. wide.

*Habitat.* Abundant everywhere along the coast in rocky tide pools of Monterey Bay, southward to La Jolla and northward to Vancouver Island region. Taken at Crescent City by W. F. Thompson and by the writer. All sizes abundant at Point Pinos, Monterey Bay, 1918, many nidosomes; eggs laid in aquarium. It is found upon the common red siliceous sponges *Plocamia lithophoenia* de Laubenfels and *Plocamia karykinos* de Laubenfels, and the rarer forms *Acarinus erithacus* de Laubenfels (not common) and *Ophalitispongia pennata* Labbé. According to de Laubenfels the color of *Rostanga pulchra*, which exactly matches that of these sponges, is not changed when the nudibranch occasionally feeds upon some sponge of a different color. This coincides with my own observations although I have not carried out such feeding experiments for any considerable length of time, neither animal adapting itself readily to aquarium conditions.

Baba (vol. 7, no. 1, p. 1, March, 1937) was almost certain that *Doris arbutus* Angas, 1864, is a member of the genus *Rostanga* and agrees specifically with *Rostanga muscula* (Abraham, 1877) in the general form and coloration of the body. He further held that *R. pulchra* MacFarland is the same form. *Rostanga arbutus* (Angas) is found in Japan exhibiting two different colors, orange and purplish black, according to the two kinds of sponges upon which it feeds. The sponge *Reniera japonica* Kadota is orange and the specimens of *Rostanga* found upon it are correspondingly bright orange, while those occasionally found upon *Reniera okadai* Kadota, a purplish black form, agree with it in color.

The identification of *Rostanga pulchra* with the Japanese form, and that one with the one from Coodge Bay, near Sydney, New South Wales, Australia, is *a priori* improbable since it would imply an enormous range geographically for this littoral nudi-



branch, extending south of the equator to 34° S. latitude and north to the middle of Japan, a distance of some 70 degrees. Such identification would require a careful comparative anatomical study of adequate material and is not to be based upon general color similarity alone.

### Genus *Aldisa* BERGH

#### *Aldisa sanguinea* (Cooper)

Plate 25, figure 8; plate 29, figure 11; plate 35, figures 17-22

*Doris (Asteronotus) sanguinea* COOPER, 1862. Proc. Calif. Acad. Nat. Sci., vol. 2, p. 204; 1863, vol. 3, p. 58.

*Asteronotus (?) sanguineus* (Cooper), BERGH, 1892. System der Nudibr. Gasteropoden, p. 111.

*Aldisa sanguinea* (Cooper). MACFARLAND, 1905. Proc. Biol. Soc. Washington, vol. 18, p. 42. MACFARLAND, 1906. Bull. U.S. Bureau of Fisheries, vol. 25, pp. 123-125, pl. 24, fig. 7; pl. 18, figs. 25-26; pl. 21, figs. 112, 114. JOHNSON and SNOOK, 1927. Seashore Animals of the Pacific Coast. Macmillan Co., New York, pp. 492-493, pl. 8, fig. 5. O'DONOGHUE, 1927. Notes on a Collection of Nudibranchs from Laguna Beach, California. Jour. Ent. and Zool., Pomona College, vol. 19, pp. 84-85, pl. 1, figs. 16-19.

Cooper's original description, renders the identification of this mollusk almost certain. It reads as follows:

"Brilliant red, with a few large black spots irregularly distributed. Surface smooth; dorsal tentacles short; branchiae composed of eight simply pinate [*sic.*] rays, extending close to the posterior end of the body."

*Body* somewhat depressed, oval, the ends about equally rounded; notum covered everywhere with small, conical tubercles.

Margin of the *notum* rather thick, not wide, but covering the foot everywhere except at the extreme tip when crawling freely.

*Foot* abruptly rounded in front, less so behind, its anterior margin bilabiate, the upper lip thin, undivided.

*Head* small, concealed between the mantle and the foot.

*Tentacles* short, auriform with a clearly marked external groove.

*Rhinophores* rather stout, the clavus dilated, conical, perfoliate, with twelve to fifteen leaves, the whole organ deeply retractile within a sheath with a low tuberculate margin. (Pl. 29, fig. 11.)

*Branchial plumes* eight to ten, simply pinnate or irregularly bipinnate, arranged in a circle around the low anal papilla, completely retractile into a pocket surrounded by a low sheath with tuberculate margin.

*Color.* The general body color is light red to dark crimson, sprinkled everywhere with very minute black spots. On the median line immediately in front of the branchiae is a large round or oval spot of black; a similar spot of black occurs in the median line just behind the rhinophores. This latter is often much elongated or divided transversely into two. Color on all ventral surfaces, stalks of rhinophores, and gill, all a light shade of the dorsum color, the plates of the rhinophores being of a dark crimson. In alcohol the black spots become greenish, the general red color disappearing entirely.

*Labial armature.* Oral cuticula thick, laterally forming a delicate armature of extremely fine, short rodlets.

*Radula* rather wide, colorless, teeth in about 70 rows, the rachis narrow, naked, the pleural teeth very numerous and slender, at least 75-100 in each half row, and of a very striking form which readily marks out this genus from any other of the Dorididae. Each tooth is composed of a slender, rod-like shaft arising from a strongly compressed, triangular base of nearly uniform size; the distal end is slightly enlarged and hollowed behind into a spoon-like form bearing on its thickened external and distal margins a single series of very small denticles which continue down the shaft for varying distances, in some cases for fully one-half the length. Inner pleural teeth about 0.5 mm. in length, the external ones ranging down to 0.03 mm.; the shaft diameter averages 0.003 to 0.004 mm., increasing toward the distal end to a diameter of 0.006 to 0.008 mm. The teeth are very flexible and readily disarranged in mounting them, rendering the exact determination of their number and the number of rows very difficult. (Pl. 35, figs. 17, 19.)

Glans penis of the *reproductive system* armed with five to six rows of small recurved hooks. (Pl. 35, fig. 22.)

*Dimensions.* Total length of a large specimen 17 mm., width 8 mm., height 6 mm. The foot of the same specimen 13 mm. in length; greatest width 6 mm.

*Habitat.* In rocky tide pools along the coast of Monterey Bay and southward. Recorded from Laguna and San Diego.

The only dorid similar in size and coloring in the Monterey area is *Rostanga pulchra* MacFarland which lacks the large black spots upon the notum.

This form is abundant in Monterey Bay and a careful study shows that it does not belong to the genus *Asteronotus* as given by Bergh (1892), but forms the second species of the genus *Aldisa*, the other species of which, *Aldisa zetlandica* Alder and Hancock, belongs to European waters.

#### EXTENDED ANATOMICAL DESCRIPTION.

*Reproductive system.* (Pl. 35, fig. 20.) The ovotestis is a lobulated organ closely attached to the dorsal and anterior surfaces of the liver. In thickness it is nearly equal to the latter organ and thus makes up at least one-half of the two. From the inner face of the left lobe the hermaphroditic duct is given off, passing immediately below the py-

loric end of the intestine downward and to the right, in front of the lesser (anterior) curvature of the stomach, thence obliquely forward beneath the spermatheca to dilate into the hermaphroditic ampulla. It is much larger than in the Dorididae of similar dimensions, reaching a diameter of 0.3 mm. The hermaphroditic ampulla is very large, its average diameter being about 0.7 mm., with a total length of about 6 mm. It is coiled in an S-shaped loop upon the lower anterior face of the anterior genital mass (pl. 35, fig. 20, *h. amp.*). At its anterior end it constricts suddenly, gives off the narrow spermatic duct, and passes into the nidamental gland. The spermatic duct is very short, dilating into the large thick-walled prostate, which describes a U-shaped loop upon the upper anterior face of the anterior genital mass, immediately above the hermaphroditic ampulla, and resting upon and against the spermatheca (pl. 35, fig. 20, *pr.*). Its distal end constricts into the muscular vas deferens, which describes a downward loop, returns and passes outward to dilate gradually into the penis (pl. 35, fig. 20, *v. d.*). The glans penis is cylindrical, blunt, about 3 mm. long by 0.04 mm. in diameter, is covered with a firm cuticle and with five or six rows of small recurved hooks (pl. 35, fig. 20, an enlargement of fig. 112, pl. 21, MacFarland, 1906).

The *vagina* is conical in form, its greatest diameter 0.4 mm., length 0.6 mm., and passes rather abruptly into the vaginal duct, a slender thin-walled tube which passes straight inward to the spermatheca, into which it opens very close to the exit of the uterine duct.

The *spermatheca* is a large spherical thin-walled organ, having a diameter of about 2 mm., and making up one-third of the volume of the anterior genital mass (pl. 35, fig. 20, *spth.*). Into the uterine duct, close to its origin, opens the narrow slender duct of the spermatocyst, a rather large, elongated, pear-shaped organ lying upon the groove between the spermatheca and the nidamental gland, and overlapping both organs. Its distal end curves outward, is doubled downward upon itself, and is continued into the short duct which opens into the uterine duct of the spermatheca, close to the latter.

The *nidamental* and *albumen glands* make up about one-third of the bulk of the anterior genital mass. The former is much larger, contains a large cavity, and partially incloses the albumen gland on its face. The duct of the nidamental gland (pl. 35, fig. 20, *n. gl. d.*) lies below and slightly behind the vas deferens and vaginal duct, their external openings occupying a similar relation.

#### Genus *Austrodoris* ODHNER

*Austrodoris* ODHNER. 1926. Further Results Swedish Antarctic Expedition 1901-1903, vol. 2, no. 1, pp. 64-68. ODHNER. 1934. British Antarctic ("Terra Nova") Expedition, 1910. Nat. Hist. Rept. Zool., vol. 7, no. 5, pp. 255-259.

Back warty (tuberculate), tentacles grooved on outer margin; radula with no median teeth, the lateral teeth smooth, with shorter or longer hooks, salivary glands usually short and broad; vas deferens convoluted, inclosed in a thick-walled sheath.

No discrete prostate.

No glans penis and no true penis, tip of vas deferens eversible to form intermittent organ.

The genus *Austrodoris* was established by N. Hj. Odhner in 1926 after a careful and detailed study of certain dorid collections from far southern waters. Concerning the tuberculate dorsum, these showed a superficial resemblance to the genus *Archidoris* which is widely distributed in northern seas and to which several southern species have been assigned. The organization of the internal organs, especially those of reproduction, however, show such marked differences from the northern forms that the creation of a new genus became a necessary logical addition. With the possible exception of two or three imperfectly known species from Australian waters, *Archidoris* appears to be a northern form, while *Austrodoris* seems to be a southern form.

The following list of earlier species of *Austrodoris*, some more or less doubtful owing to imperfect information, would seem to bear out the distribution of the two genera as indicated. However, with the addition of the new species *Austrodoris odhneri* here described from the Monterey Bay region, the southern circumpolar range of the genus is extended to the northern hemisphere.

1. *Austrodoris rubescens* (Bergh, 1898)  
Punta Arenas, Tierra del Fuego; South Georgia, Falkland Island
2. *A. michaelsoni* Odhner, 1926  
Tierra del Fuego, Ushuai, Beagle Channel
3. *A. crenulata* Odhner, 1926  
Tierra del Fuego
4. *A. tomentosa* Odhner, 1934  
McMurdo Sound; off Oatlands
5. *A. mcmurdensis* Odhner, 1934  
McMurdo Sound
6. *A. nivium* Odhner, 1934  
McMurdo Sound
7. *A. australis* (Bergh, 1884)  
Kerguelen Island
8. *A. kerguelensis* (Bergh, 1884)  
Kerguelen Island; Port Otway, Patagonia
9. *A. falklandica* (Eliot, 1907)  
Falkland Island
10. *A. fulva* (Eliot, 1907)  
Spencer Cape, South Australia
11. *A. antarctica* (Hedley, 1916)  
South Australia

12. *A. granulatissima* Vayssi re, 1917  
(*A. antarctica*?)  
McMurdo Sound; Off Oatlands Point, Ross Sea
13. *A. peculiaris* (Abraham, 1877)  
Port Lincoln, South Australia
14. ?*A. violacea* (Quoy and Gaimard, 1832) *vide* Pruvot-Fol, 1934
15. *A. odhneri* MacFarland, new species  
Monterey Bay, Point Pinos, Point Lobos, California

***Austroductor odhneri* MacFarland, new species**

Plate 26, figure 1; plate 29, figure 14; plate 36, figures 1-19

DESCRIPTION OF LIVING SPECIMEN.

Based on a specimen received June, 1904, from M. H. Spaulding, and collected at Cypress Point.

*Body.* General body form similar to *Anisodoris* and *Archidoris*, elliptical elongate, rather broad and rather highly arched. Notum firm, thickly set everywhere with low, rounded to conical, large and small tubercles, the largest near the median line, the smallest in the marginal zone, but the two intermingled regularly. Their diameter range is from mere points to 1, 2, and 3 mm. These tubercles are spiculate as indicated from the touch. Free mantle margin undulating, rather broad and moderately thin, the under surface slightly granular to the touch, about one-fourth to one-fifth the body width.

*Foot* broad, the tail thin, rounded, and concealed beneath the mantle except the tip when the animal is crawling freely. Anterior margin rounded, bilabiate, the upper lamina entire, not notched.

*Mouth* small, the lips but slightly inflated, flanked on either side by short tapering, somewhat triangular tentacles. These curve downward from the sides of the mouth, being 5.5 mm. to the tip, bearing a shallow longitudinal groove on the external margin.

*Rhinophores* deeply retractile within thin undulating sheaths, the margins bearing a single row of small conical tubercles. The pockets are large, being 7 mm. in diameter, the distance between them being one-third to one-fourth the maximum width of the dorsum at this point. Rhinophore stalks short, conical, bluntly pointed, forming about one-third the length of the whole organ, the clavus conical, perfoliate, with about twenty to twenty-four leaves, the larger of which have the appearance of being divided behind. Careful study seems to confirm that short intermediate leaves occur with some irregularity. (Pl. 29, fig. 14.)

*Eyes* not conspicuous, being well below the surface.

*Branchial opening* well back on mid-dorsum, wide, its low margin formed by medium-sized papillae of nearly uniform appearance. Diameter of opening about one-

fourth the maximum width of notum. Gill plumes seven, tri- and quadripinnate, wide-spreading, recurved, covering nearly the entire width of the dorsum; arranged in a nearly complete circle around the prominent anal papilla, close in front of and to the right of which is the small inconspicuous renal opening.

*Genital opening* well forward on right side, nearly opposite right rhinophore in anterior third of body length.

*Color* entirely white everywhere; looking directly upon the dorsum, the viscera and mandibular mass show through as a large area of soft mauve pink. The tips of the tubercles which cover the dorsum have, on the larger ones, an appearance of a white encrustation. This very marked white occurs on the edges of the gill plumes and those of the rhinophore leaves. The edges of the mantle are so closely covered with the small tubercles that the appearance is of pure-white lines. The finer divisions of the gill are so undulating and transparent, with the pure-white edges, that it can be compared only to a handsome plume, and is so rightly called.

*Dimensions of living specimen.* Dorsum length 89 mm., width 42 mm., height, maximum, 20 mm., foot length 70 mm., width 31 mm., rhinophore height 12 mm., stalk 4 mm., distance apart from inner edge of sheath 11 mm., sheath width 7 mm., sheath height 1 mm., extended tip to tip 23 mm.

#### DESCRIPTION OF ALCOHOLIC SPECIMEN.

This specimen is fairly flaccid, the dorsum thickly tuberculate but somewhat flexible. The foot wide, rounded, the tail blunt, concealed below the mantle. The anterior margin bilabiate well back along the side. Mantle margin broad, overlapping the foot. Head region very distinct, mouth a longitudinal slit, oral tentacles tapering, slender, curved forward from the sides of the mouth mass. Oral tentacles 5.5 mm. long. Rhinophores retracted, the tips showing inside, the sheath low, its margins tuberculate in a single row, about eighteen large and small tubercles bridge the space between.

*Dimensions of alcoholic specimen.* Total length in a straight line 82 mm., total length along curve of back 86 mm., maximum width in straight line 51 mm., approximate height 26 mm., total length of foot 64 mm., width of foot 22 mm., width of mantle edge beyond foot 12 mm., length of prebranchial notum 85 mm., length of post-branchial notum 11.5 mm. Transverse line between the rhinophores has about 16 large and small tubercles.

*Habitat.* All specimens were taken from Monterey Bay and vicinity. The genus is of rare occurrence. The earliest recorded specimen was dredged from the Bay in 1898. From Cypress Point one specimen was collected by M. H. Spaulding, June, 1904. From the same place the largest specimen recorded was taken by W. K. Fisher, July 7, 1925. At the same tide two large specimens were taken well out on the right side of the Large Tide Pool, Point Pinos. A large one was found by H. Heath, place and date not re-



corded. Several small (comparatively) specimens have been collected within the last fifty years, but the species is sought eagerly and rarely found.

#### EXTENDED ANATOMICAL DESCRIPTION.

*Integument.* The notum is thick, thinning away somewhat toward the margins. The calcareous spicules are of two kinds, the first, spindle-shaped or slightly bent, is found close below the low non-ciliated epithelium directed perpendicularly to the surface. In a large specimen they range up to a maximum of 0.204 mm. in length by 0.018 mm. in diameter, and are of the form shown in plate 36, figure 15. In but one instance only was branching noted.

The second form of spicule occurs in a loose, interlacing network of elongate unbranched rods arranged in bundles in the deeper layer of the integument, from which, at intervals, branches extend outward into the papillae of the outer surface. Associated with these rodlets in the meshwork are numerous spindle-shaped spicules similar to those in the tubercles but usually smaller. The rods are frequently interrupted, possibly by fractures, but in practically every case the break is exactly transverse and the interruption is bridged across by the external membrane and the internal contents.

The spicules of the integument are well shown in thick celloidin sections stained lightly with haematoxylin or carmine and are readily distinguishable from connective tissue, nerve, and muscle fibers. In the spindle-shaped ones the calcareous portion forms a thin, hollow, highly refringent peripheral layer surrounding a central cavity filled presumably with faintly staining cytoplasm and an axial elongated nucleus. Over the external surface of the spicule there appears to be a very thin layer of cytoplasm. (Pl. 36, fig. 17.)

In cross sections there appear: (1) a thin deeply stained outer layer, (2) a thick layer, pale yellow in color, (3) a central area apparently empty or containing a very deeply staining round nucleus-like mass. Layer 2 seems to thicken at the apex of the spicule. Outside of layer 1 there appears to be a thin colorless layer, containing rounded or flattened nuclei, as a distinct sheath. (Pl. 36, figs. 18, 19.)

These spicules seem to differ from others so far described in Opisthobranchs in that they are not solid but hollow structures.

Freehand cross sections of the mantle margin were placed in dilute potassium hydroxide. Everywhere between the spicules were seen myriads of fine granules of a mineral nature. These were dead white, rounded, and existed singly or in clumps.

The closely set tubercles of the notum are low hemispherical or bluntly conical in form, the largest being flattened as a rule. Opening in the grooves between the tubercles are a multitude of closely set, short, tubular, simple or compound glands. The low cuboidal epithelium of the tubercle surface (*a*) becomes replaced by cells of a columnar form as they pass into the body of the gland, a very short duct (*c*) marking the transition. The simple or branched fundus of the gland is somewhat dilated, but not nearly so much as described by Odhner (1926) for *Geitodoris patagonica*. Its epithelium con-

sists of tall columnar cells, many of which are distended with a clear mucoid secretion and appear in the familiar goblet-cell form. (Pl. 36, figs. 16, 16, *a*, 16, *c*.)

*Mouth.* The lips are somewhat distended by fixation changes in most of the specimens. They are covered by a strong simple cuticula which extends back through the mouth tube and is succeeded by the radula. The cuticle presents no differentiation into rodlets or other modifications of the labial armature. Faint vertical, as well as horizontal, striations or lamellations may be observed. The *pharyngeal bulb* is conical in shape, flattened behind, the radula sac forming a light median protuberance behind and below.

*Radula.* (Pl. 36, figs. 1-6.) The deeply grooved radula, when flattened out, is rectangular in form, 8.4 mm. in length by 6.8 mm. in width. The teeth are in about thirty-four rows, the first four or five worn, blunted, and incomplete. No median tooth is present and some fifty-five laterals are found in a typical row. The lateral teeth are strongly hooked, the innermost three or four of each row are quite small (pl. 36, fig. 5), the remainder increasing in size and becoming fairly uniform until the outermost two to five which decrease rapidly, the outermost one being represented only by a basal rudiment in many cases. (Pl. 36, fig. 1.)

From the relatively narrow and elongated base the strong, nearly erect hook is borne from its outer anterior border, and is directed obliquely toward the median line. (Pl. 36, figs. 2, 3, 4.) The length of the base (pl. 36, fig. 6) of a typical lateral tooth is .5 mm., the vertical height of the tip of its hook above the base line is .4 mm. The radula formula may be expressed as 34 (55·0·55).

*Blood glands.* Large, flattened, lobulate blood glands are present upon the dorsal surface of the pharyngeal bulb, the larger somewhat U- or J-shaped in front of the central nervous system, the slightly smaller one close behind it. In a second specimen the anterior blood gland is paired, the right one slightly broader and longer than the left. It is 9.6 mm. in length, 1.8 mm. in width at its anterior, and 2.9 mm. wide at its posterior end. (Pl. 36, fig. 12.) The smaller blood gland on the left measured 6.7 mm. in length and 1.4 mm. in maximum width. Behind, it narrows to a filamentous extension curving toward its fellow on the right. (Pl. 36, fig. 12.)

*Salivary glands* finely lobulate irregularly band-like. (Pl. 36, fig. 11.) In the study of the reproductive system use was made of a faultless series of celloidin sections cut at 100 $\mu$  thickness to supplement the careful dissection of a second specimen.

*Reproductive system.* The *ovotestis* covers the anterior ends of the liver in a mass of finely divided lobules from which a multitude of fine ducts arise and unite to form the main hermaphroditic duct. Close in front of the right liver lobe lies the adnexed *anterior genital complex* wedged in between the pharyngeal bulb and the right body wall. It is of a flattened ellipsoidal form, its more convex outer face in close contact with the body wall, while its inner is more flattened and irregular. Its longer axis

is inclined forward, its highest point being occupied by the relatively small spherical spermatheca.

Upon the inner face of the complex appears the finely divided surface of the compact *albumen gland*, almost surrounded by the coarser convolutions of the *mucous gland* forming a nearly complete ring encircling it.

The slender *hermaphroditic duct* passes across the narrow interval between the right anterior lobe of the liver and the adnexed anterior genital complex and dilates to form the rather narrow whitish *hermaphroditic ampulla*, approximately 1.5 mm. in maximum diameter and 35 mm. long. The *ampulla* passes across the inner face of the adnexed genital mass in a sinuous course, forms a closely convoluted coil upon the anterior face, curves upward, narrows, and passes into the complex close below the spermatheca. Here, as shown by serial sections, it gives off the *vas deferens* and opens into the cavity of the complex close to the entrance of the duct of the albumen gland.

The *vas deferens* (pl. 36, fig. 7) emerges as a thick tube, about 0.5 mm. in diameter, passes downward in a zigzag course, and forms a dense mass of convolutions upon the lower anterior border of the adnexed genital complex, with its course in general upward. The approximate length of this proximal thick segment of the *vas deferens* is 14 to 16 mm., its diameter 0.5 to 0.6 mm.

Its somewhat irregular lumen (pl. 36, fig. 8) is due to low ridges caused by variable heights of the lining epithelium. It is lined by a high ciliated columnar epithelium (pl. 36, fig. 9) made up of rather slender cells packed with fine acidophile secretion granules, and with small, oval, deeply staining nuclei near the basal end. These cells range from 0.075 to 0.15 mm. in height. Between them, at the beginning of their outer third, is a row of small, flattened, deeply staining nuclei, apparently belonging to slender cells wedged in between the larger granular ones, though the thick preparations at hand do not render their true relations evident. The cilia appear in clumps, not uniformly distributed, and seem in places to be borne by the slender interstitial cells only, and not by the wider granular cells. The epithelium is raised into a few low ridges by the varying height of its cells.

No individualized prostate gland is present.

Without doubt this segment of the *vas deferens* has a secretory function, probably corresponding to that of the discrete "prostate gland" of the Discodorinae (*Anisodoris*), while its dilatation in the first segment of its course resembles that described by Bergh for *Doris* (syn. *Staurodoris*) *verrucosa* (Cuvier) and ascribed by him to a very high lining epithelium.

The epithelium of the thick segment of the *vas deferens* is surrounded by thin muscular and connective tissue layers 0.012 mm. in thickness. The inner muscle fibers are mainly circular in arrangement, with but few longitudinal ones. Only a minimal amount of loose connective tissue attaches the various loops of the thick segment to each other and to the surface of the underlying glands.

At the upper anterior border of the complex, the thick segment of the *vas deferens* (pl. 36, fig. 7) suddenly narrows and passes into the rounded end of a dense

enveloping sheath of musculo-fibrous tissue (*a*) with ill-defined boundaries. It curves upward, outward, and downward along the external face of the complex to the body wall and the external genital opening where it is joined by the vagina parallel to it. The two are united by a connective tissue slightly less dense than that forming the sheath of the distal segment of the vas deferens. Through this sheath the narrowed vas deferens winds in a very irregular course until the external genital cloaca is approached. The diameter of the vas deferens here is reduced to about 0.24 mm., the lining epithelium to 0.018 mm. in height. (Pl. 36, fig. 10.) Surrounding the epithelium is a thick layer of muscle fibers inclosed in turn by an outer tunic of fairly compact connective tissue, set off from the outer sheath by cleft-like vascular spaces, bridged across at intervals by fibers.

No differentiated *penis* as such is recognizable, the vas deferens terminating in a papilla which is variable in extent depending upon the degree of eversion undergone by the spermatic canal. The papilla opens into a roomy canal leading into the genital cloaca, the wall of which is a continuation of the sheath of the vas deferens. It is lined by a low columnar epithelium and exhibits a great number of low, closely set, longitudinal folds which proximally are continued into similar folds at the tip of the papilla of the vas deferens.

*Vagina and vaginal duct.* (Pl. 36, fig. 7.) The vagina opens externally into the genital sinus close behind the opening leading to the vas deferens papilla, being about 10 mm. long by 2.4 mm. wide. Its lumen is broad and incompletely divided lengthwise by two opposed lateral folds, one from the front, the other from the rear wall. At its proximal end the vagina curves forward below the spermatheca and narrows into the vaginal duct which receives the short duct of the spermatheca and, after a quite short convoluted course of some 3 mm., the duct of the spermatocyst, and then continues as the short uterine duct to open into the nidamental gland cavity.

*Spermatheca.* The relatively small spermatheca rests upon the upper anterior border of the adnexed gland complex. It is nearly spherical in form, thin walled, about 3.8 mm. in diameter, and filled with a coagulum of spermatozoa, cellular debris, and mucus. Its epithelium is made up of clear columnar cells, approximately 0.25 mm. in height, with large deeply staining oval nuclei located midway of the cells' height. They appear to bear short cilia, but these are so imbedded in the coagulum that they cannot be clearly made out. The lining epithelium rests upon a thin compact layer of muscle fibers followed by an adventitia of connective tissue, the whole thickness of the wall approximating 0.072 mm.

*Spermatocyst.* The spermatocyst is pyriform in shape, its maximum transverse diameter reaching 2 mm., its tapering duct measuring the same in length. Its stout muscular wall is nearly twice as thick as that of the spermatheca, and is lined by a low ciliated epithelium in close contact with which are the heads of myriads of mature spermatozoa, their tails directed radially toward the center of the spermatocyst.

As shown in figure 7 of plate 36, the duct of the spermatheca leads directly into the narrowed tip of the vagina. Its wall is thin and muscular, its low cuboidal epithelium is elevated into a small number of longitudinal ridges continuous into those of the vagina lining. At about 1.4 mm. from the spermatheca, the uterine duct joins the duct of the spermatocyst and continues on to pass into the gland complex opening into its lumen.

The present species agrees with *Austrodoris* as described by Odhner (1926, 1934) in the absence of the glans penis, as such, and the lack of a separate gland, and in the presence of the dense sheath within which the vas deferens winds. It differs, however, from the species described by Odhner in that the vas deferens is divided into two distinct segments, the proximal thicker one being free from the sheath, while the slender distal one is inclosed within it. (Pl. 37, figs. 8, 9, 10.)

Odhner makes no statement as to the microscopic structure of the vas deferens, but states that it has no prostatic part (as in *Doris* and *Archidoris*), nor prostate gland (as in *Anisodoris*).

*Central nervous system.* (Pl. 36, fig. 13.) The main ganglia are concentrated above the beginning of the oesophagus, and are connected below the latter by the relatively long commissures. The cerebral ganglia are approximately triangular in dorsal view, narrowing behind between the parietal ganglia, and are in close contact though not fused. The olfactory ganglia are practically sessile upon the cerebral ones, the eyes are borne upon extremely short optic nerves.

The buccal ganglia (pl. 36, fig. 14) are united to the cerebral pair by relatively long cerebro-buccal connectives. Closely united to each is a rounded gastro-oesophageal ganglion containing one very large nerve cell body and a number of small ones.

The pleural commissure is long, but was injured in the dissection so that its exact relationships were not made out. The genital ganglion is borne on the right side at some distance from the right pleural ganglion.

### Genus *Doris* Linnaeus

#### *Doris* (*s.l.*) species

Plate 25, figures 1-6

On May 8, 1946, a small white dorid was collected at Arch Rock Pool, Newport Bay, California. Some drawings and brief descriptive notes were made. The detailed anatomy and taxonomy were not worked out.

*Notum* soft, covered with thickly set, short, slender, blunt papillae; margin broad, 1.2 mm., edge thin.

*Head.* Tentacles slender, pointed, curved outward and forward, breadth between the tips 7 mm.



*Foot* broadly bilabiate in front, the upper lip notched in median line; elongate elliptical in outline, nearly equally rounded in front and behind. Foot length 22 mm., width, at anterior end, 7 mm.

*Rhinophores* retractile within sheath, bearing closely set slender papillae. Clavus dilated, pointed, perfoliate, 16 to 18 plates. A shallow groove up middle line of clavus in front, a ridge behind. Interval between one-third of body width at that part.

*Gill* plumes about six, tripinnate, forming a wide vase-shaped cluster when extended. The arrangement of the delicate colors is most decorative.

*Body color.* rhinophores, gills all white. The viscera give the dorsum a darkened area. A number of large, light-brown spots, vandyke brown, one in front of the rhinophores, a pair immediately behind them, a pair in front of the gills, and another unequal pair are found about midway on the dorsum. In addition there are a great number of minute flecks over the dorsum. The thin margin edge thickly set with minute white and brown spots forming a border. All papillae are capped with a dead-white spot.

#### RHINOPHORES OF THE DORIDACEA.

The majority of the Doridacea have foliate rhinophores which may be completely retracted into special cavities with or without prominent margins and sheaths. The margins may be entirely smooth, of uniform height, or they may be undulating, irregular, notched, unequally prolonged into nodular processes or papillae, fairly equal in size, or showing marked differences as processes.

The rhinophore stalk is usually completely retractile within the cavity bounded by its sheath which is to be regarded as the differentiated marginal boundary of the notaeum. The stalk may be smooth, tapering to a usual blunted extremity, or bear various modifications of its surface in the form of leaf-like elevations lodging the sensory endings of the rhinophore nerves. This portion is usually termed the clavus as distinguished from the smooth stalk below, and its tip above.

In *Corambe*, instead of the usual oblique platelets, the rhinophore bears an enveloping pair of wing-like plates, attached in front and below to the stalk, being free only at the upper one-fourth, the margins curving downward and backward, meeting behind as they merge into the basal region of the stalk.

Within these, and parallel to them, is an inner pair of narrower platelets arising from the sides of the stalk. From the mid-line of the stalk, posterior, a median posterior plate, forming scarcely a ridge, may be found.

Curiously enough, the outer pair of these wing-like plates was described by H. Fischer (1892) as the rhinophore sheath split down its full length behind although his figure 4. plate 9, clearly shows the true sheath below as a low, smooth-edged wall encircling the whole rhinophore stalk and its wing-like plates.



## Subfamily ARCHIDORIDINAE

Genus *Archidoris* BERGH

*Archidoris* BERGH. 1878. Malacol. Untersuch., in Semper, Reisen im Archipel der Philippinen, Bd. 2, Heft 14, p. 616. BERGH. 1879. Proc. Acad. Nat. Sci. Philadelphia, vol. 31, p. 106.

*Archidoris montereyensis* (Cooper)

Plate 27, figure 8: plate 37, figures 1-10

*Doris montereyensis* COOPER. 1862. Proc. Calif. Acad. Nat. Sci., vol. 2, p. 204; 1863, vol. 3, p. 58.

*Archidoris montereyensis* (Cooper), BERGH. 1878. Mal. Unters., Heft 14, p. 624. BERGH. 1879. Nudibr. Moll. North Pacific Ocean. Proc. Acad. Nat. Sci. Phil., vol. 31, p. 107. MACFARLAND, 1906. Bull. U.S. Bureau of Fisheries, vol. 25, pp. 114-116, pl. 23, fig. 4; pl. 18, figs. 1-5. O'DONOGHUE. 1921. Nudibranchiate Mollusca from Vancouver Region. Trans. Roy. Can. Inst., Toronto, vol. 13, pt. 1, pp. 154-156, pl. 1, figs. 7, 8. O'DONOGHUE and O'DONOGHUE, 1922. Trans. Roy. Can. Inst., Toronto, vol. 14, pt. 1, p. 137, pl. 3, fig. 5. JOHNSON and SNOOK. 1927. Seashore Animals of the Pacific Coast. Macmillan Co., New York, p. 491, pl. 8, fig. 2.

*Body* elongate elliptical, but slightly depressed, the ends nearly equally rounded, notacum not hard, slightly arched, everywhere closely set with low, conical tubercles. (Pl. 27, fig. 8.)

*Foot* elongate, elliptical, the anterior margin bilabiate with no median notch. (Pl. 37, figs. 1-7.)

*Head* small, tentacles auriculate with an external groove.

*Rhinophores* stout, retractile into conspicuous sheaths with tuberculate margins, perfoliate with twenty-four to thirty leaves on each side.

*Branchial* plumes seven, spreading, three or four pinnate, retractile within tuberculate sheath.

*Ground color* light yellow, dorsum and foot alike. The dorsum has a dusky appearance owing to extremely minute brown, greenish brown, or black dots thickly sprinkled over the dorsum everywhere. Larger patches of the same color are scattered over the dorsum upon, as well as between, the tubercles, and more sparingly over the branchiae which are a delicate brown shade. The plates of the rhinophores, a deeper yellow, show clearly upon the lighter colored clavus.

Length up to 50 mm., width to 25 mm., height to 12 mm.

*Radula* colorless, broad and short, deeply grooved, the teeth in 33 rows; rachis narrow, naked, pleurae multidentate with 42 to 49 strongly hooked, compressed teeth, each bearing a strong, wing-like expansion on the inner margin of the shaft. Radula formula 33 (42-49-0-42-49). (Pl. 37, fig. 7.)

*Reproductive system* (pl. 37, fig. 9). The everted glans penis is conical, unarmed, with no trace of a prostate gland upon the long, 28 to 30 mm. vas deferens. It is long and slender, about 7 mm. by 2 mm. at the base. The tip, about .5 mm. in diameter, is smooth, bent upward and backward. Close to the base arises the slender muscular vas deferens which describes a number of closely coiled loops. The hermaphroditic ampulla is a thin-walled sac in close loops upon the anterior dorsal margin of the genital mass.

The vaginal opening is situated immediately behind the penis, above the duct of the nidamental gland. The vaginal duct courses obliquely upward to the posterior end of the spermatheca where it receives the long slender duct from the spermatocyst at the juncture of the uterine duct, then opens into the spermatheca. (Pl. 37, fig. 10.)

*Habitat.* This species is comparatively common in Monterey Bay, occurring in rocky tide pools at nearly all seasons of the year. Quite common upon wharf piling at Monterey. Not rare along the California coast and recorded from Alaska to San Diego. Recorded by Abraham (1877) as *Doris tuberculata* Cuvier as from Victoria; corrected by O'Donoghue (1926) to *A. montereyensis* (Cooper) after an examination of the original specimens in the British Museum.

Bergh (1900) recorded *Archidoris tuberculata* (Cuvier)? and *Archidoris nyctea* Bergh, as having been taken at Bare Island, between Vancouver Island and mainland British Columbia. O'Donoghue (1926) made no mention of these in his list. *Archidoris nyctea* Bergh seems to have a row of irregular spurious median plates, which led Bergh to establish the new species upon the one specimen. Study of further specimens is much to be desired.

#### Genus *Petelodoris* BERGH

*Petelodoris* BERGH. 1882. Beitr. Kenntn. d. Japan. Nudibr., II. Verh. k.-k. Zool. Bot. Gesellsch. Wien, vol. 31, pp. 228-230, pl. 7, figs. 4-15. Type *Petelodoris triphylla* Bergh, Enoshima, Japan.

*Body* subdepressed, notaeum with median carina, densely spiculate, thickly beset with very small hispid papillae; front margin of branchial aperture produced into three conspicuous valve-like lobes more or less completely closing the opening when the branchiae are retracted within it, branchiae few (three), tripinnate; oral tentacles small, acuminate; rhinophores borne within elevated hemispherical hillocks, completely retractile within these hispid thickened sheaths.

*Labial disk* cuticle smooth, radula rachis narrow, naked, the pleural teeth not numerous, hooked.

*Glans penis* conical, unarmed, prostate gland absent.

The genus *Petelodoris* Bergh, 1882, was based upon a single specimen of *P. triphylla* collected by C. Körbl in 1877 upon the east coast of Enoshima, an island promontory upon the north coast of Sagami Bay, south of Yokohama, Japan. It is listed by Baba (1937, 1949), but its capture is not recorded, though the locality is so

near the area intensively studied by H. M. the Emperor Hirohito and his staff that its recapture in the near future is very probable. Dr. Körbl was with a Geological party when the specimen was found.

Its general characters such as the smooth oral disk, the unarmed pleurembolic glans, and the absence of a discrete prostate, place it in the subfamily Archidoridinae, while its densely spiculate notaeum, its elevated hemispherical rhinophore areas, its median dorsal carina, and especially the elevated, trilobed, valve-like, anterior margin of the branchial pocket distinctly set it off from the other genera of the subfamily so far described.

It is especially interesting to find the following second species of the genus in the Monterey region, though here, too, the paucity of material leaves much to be learned about it.

***Petelodoris spongicola* MacFarland, new species**

Plate 27, figures 1-5; plate 30, figure 16; plate 37, figures 11-21

Two living specimens were taken on June 17, 1908. These were most carefully studied and measured, and preliminary drawings were made. The following description was made at this time.

*Body form* elongate oval, sides parallel, but slightly depressed, mantle margins wide with thin sinuous edges. A prominent irregular ridge extends backward along the mid-dorsal line of the notaeum from between the rhinophores to the anterior face of the gill sheath. This forms a high knob-like hump about midway of its length from which a few irregular ridges extend laterally.

The *notaeum* is everywhere thickly set with minute hispid papillae, conically shaped with straight sides. These are quite conspicuous around all margins where they extend beyond the edges. They are crowded with interlacing calcareous spicules. The general effect of these structures gives the surface of the animal a harsh, brittle feel resembling somewhat the calcareous sponge upon which it is found. (Pl. 37, figs. 19, 20, 21.)

The *head*, as seen from below, is slightly square, while the posterior end of the mantle is rounded with the tip of the tail showing beyond.

The *labial tentacles* are slender, triangular, tapering to blunt tips directed outward laterally and forward from the sides of the oral region of the head, being 3 mm. in length. They arise immediately in front of the union of the dilated lobes of the anterior foot margin with the head.

*Foot* elongate-elliptical, its under surface smooth, without spicules, the rounded posterior end showing beyond the widely overlapping mantle. Details of the anterior end were clearly seen in the alcoholic specimen. This is rounded, bilabiate, the upper lamina prominent, deeply notched in the center by a square-shaped incision, at the sides

of which it is much thickened into elliptical lobe-like portions which abruptly narrow toward the median line and unite behind the mouth with each other and the head. Laterally the superior lamina curves widely around to unite with the inferior one at the antero-lateral border of the foot. (Pl. 27, fig. 4.)

*Rhinophores* conical, the clavus perfoliate with sixteen to eighteen leaves, the tip terminating bluntly, projects above the rim of the sheaths, but the stalk is usually concealed. The clavus is distinctly grooved in the midline in front and behind, giving it a slightly flattened appearance. The rhinophores are surrounded by thick-walled cylindrical sheaths with blunt rounded margins and closely covered with hispid papillae similar to those of the notaeum. In the contracted condition, and after fixation, these short cylinders become transformed into two large hemispherical hillocks, the margins being in-rolled following the contraction of the rhinophores. These stand up above the notaeum and markedly change its appearance from the living state. (Pl. 27, figs. 1, 5.)

*Branchiae* three, tripinnate. These are directed backward from beneath three thick, prominent, bluntly triangular lobes expanded upon the anterior and antero-lateral margin of the elsewhere quite low sheath, bounding the circular branchial cavity into which the gills are retractile. These lobes are thick, externally convex, and thickly set with hispid spiculate papillae, their inner surface in contact with the gills is smooth. Posteriorly these lobes are continued into the low thin sheath surrounding the remainder of the branchial pocket. The hinder end of the median dorsal ridge of the notaeum continues up and dies away upon the mid-line of the anterior median lobe.

The arrangement of the three gills corresponds to that of the three marginal lobes, one antero-median flanked on either side by an antero-lateral one. From the posterior side of the stalk of each antero-lateral gill arises a strong basal branch, passing obliquely backward, at first sight giving the appearance of a separate gill plume, increasing the total number to five rather than three. Limited material at hand prevents the determination as to whether this basal branch may not at times form an independent gill. (Pl. 27, figs. 2, 3.)

In the living animal the *anal opening* is covered by the gill plumes and their lobes.

The *eye* is inconspicuous.

The *reproductive papilla* in a fixed specimen is broad, 19 mm. posterior to the anterior border of the foot. The curved tip of the slender, tapering glans protrudes from the anterior of the genital aperture.

The single specimen used was very unfavorable for dissection, its brittleness making it impossible to make out clearly the finer details of the reproductive organs. The glans penis is tapering and unarmed, the vas deferens is long and without a separate prostate gland, the unarmed vagina seems to open into a single receptaculum (spermatheca), and no spermatocyst could be found. The hermaphroditic ampulla was large.

*Lip disk* and its continuation as the lining of the oral tube covered by a thick smooth cuticle somewhat corrugated longitudinally by local contraction. Lips thick, distended with short labial glands, oral tube from the mouth margin to the bulb 1.4 mm. long.

*Pharyngeal bulb* short and wide, somewhat cordate in form as seen from above, 2.6 mm. long, 2.7 mm. wide, and 2.1 mm. high. The radula sac projects slightly in the median line behind. A pair of large disk-like salivary glands lie close to the anterior end of the oesophagus, their short ducts opening above the radula.

*Radula* with fifteen oblique rows of large, strongly hooked teeth resting upon a strong cuticle which lines the whole cavity, the rachis naked, rather narrow. Pleural teeth twenty to twenty-three in complete half-rows, in form strong compressed hooks, the innermost and the outermost two or three smaller than the remainder. The base of an average lateral tooth measures about 0.02 mm. in length, the hook 0.012 mm. in height. The innermost is about 0.1 mm. long, the outermost about 0.075 mm. long. Height of the teeth ranges up to 0.18 mm. Plate 37, figures 11-18 show the teeth and typical laterals. Radula formula 15(20-23·0·20-23).

*Color.* (Pl. 27, figs. 1-5). The general color in life is raw umber mottled everywhere with small dark-brown to black spots which seem to be confined to the spaces between the dorsal papillae. The edges of the mantle, foot, ridges of the dorsum, and gill plumes are a pale shade of the body color. The rhinophore lamellae are a marked pale green, while sprinklings of pink are seen in the general color along the mid-dorsal ridge.

Immediately behind the rhinophores and anterior of the outer branchial lobes are groups of small and large dark spots. Upon each side of the posterior end of the central ridge is a large, round, black spot which seems destitute of papillae. The dark markings between the papillae give the effect of pore-like openings, the whole surface closely resembling the encrusting sponge upon which it is found.

*Dimensions* of the largest specimen taken: length over all, when crawling freely, 64.3 mm., maximum breadth 30 mm.; maximum height at crest of dorsal ridge 23 mm.; height of rhinophore sheath when extended 3.5 mm., its width 3.5 mm.; length of rhinophore clavus 4 mm.; length of labial tentacles 3 mm.

A second specimen measured 35 mm. in length, 11.5 mm. in breadth, and 13 mm. in greatest height.

*Dimensions* of the same large specimen after fixation are: length 34 mm., width 14 mm., height 8 mm., at dorsal ridge elevation. Mantle margin 5 mm. and the anterior end of foot 7.8 mm. in width. Contracted rhinophore sheaths, as rounded hillocks, have a basal diameter of 2.3 mm., distance between 1.3 mm., height 1.3 mm.

The measurements of *Petelodoris triphylla*, the Japanese genotype, as given by Bergh are: length over all 14 mm., greatest breadth 8 mm., maximum height 5 mm.



*Habitat.* Found upon encrusting sponges on the under surface of large rocks at extreme low tide at Point Pinos and Point Lobos, Monterey Bay, California. The heavy surf usually makes collecting in such places exceedingly difficult and without doubt renders the animals apparently very rare there. But four specimens have been taken, three during the spring and summer of 1908; two by Dr. Harold Heath, one at Point Lobos in the spring, one on June 17, 1908, at Third Beach. The writer on the same day took one from the Large Tide Pool, Point Pinos, under a granite boulder and from the same place one was found by E. A. MacGregor in December, 1908. Despite repeated attempts since, no more have been found.

Of these only two specimens remained on November, 1949, when final work began.

#### DESCRIPTION OF LARGE SPECIMEN.

*Body* firm, apparently densely spiculate, elongated, narrow in proportion to the length.

*Foot* rounded in front, bilabiate, the upper lamina prominent in advance of the hinder one which is entire and rounded. The upper one attached on the outer angles, thickened, and prolonged into two fleshy smooth lobes deeply notched and separated in the mid-line where the mouth is located. The two labia of the foot are separated by a deep transverse cleft, the hinder margin of the superior labrum arching down- and backward over it in the preserved condition. (Pl. 27, fig. 4.)

*Rhinophores* contracted within high rounded sheaths, densely set with minute papillae, appearing as two rounded hemispherical hillocks, the opening nearly closed by contraction. Basal diameter 2 mm., height 1 mm., interval between 1.2 mm. Distance of anterior margin of notum in front of sheaths, 5 mm.

A narrow median ridge, its top rounded, begins close behind the rhinophores in the mid-line of the notum and extends back to the anterior base of the median lobe of the three guarding the branchial opening. Its length is 11.3 mm. to mid-elevation, 8.2 mm. to the hind end. In the fixed specimen it appears as a fairly uniform ridge, about 1.7 mm. in basal diameter, and is flanked on either side by two similar but much lower and less prominent ridges in the notum, the outer one extending laterally to about the beginning of the free marginal area of the notum. Slightly behind the mid-length of the median ridge, it enlarges into a rounded prominence about 3 mm. in length and 2 mm. in width.

The *branchial plumes* are well extended, directed backward beneath a three-lobed projection of the integument about them. The lobes are convex above, thick with rounded ends and densely papillose. They are incompletely separated from each other. Their basal width, transversely, is about 5 mm., the oblique height of the left lobe is 3 mm.

The *spicules* of the notaeum are elongate spindle-shaped, not quite straight, with faintly irregular surfaces. (Pl. 37, figs. 20, 21.) They measure up to 0.45 mm. in length



by 0.036 mm. in diameter. Contrary to the usual description of the spicules of Dorididae, they are clearly hollow and contain usually more than one nucleus with cell remnants forming a central strand in the lumen. The spicule wall is rather thick, in the largest specimens measuring 0.003 mm. In some cases the lumen is very small, in others it reaches one-third the total diameter of the spicule.

It is finely lamellate usually, and toward the ends of the spicule the cavity is bridged across by numerous very thin convex partitions, their convexities directed toward the ends of the spicules. (Pl. 37, fig. 20.)

The spicule is inclosed within a very thin, resistant boundary sheath, formed by numerous flattened cells surrounding it. After decalcification, especially in celloidin sections, this sheath is left intact as a sharply defined membrane, the calcareous wall is dissolved away leaving traces only of its former presence. In polarized light the spicule is anisotropic uniaxially.

The slender *papillae* of the notaeum are strengthened by several slender spicules extending through their full height (pl. 37, fig. 19) and diverging somewhat, their tips usually projecting beyond the surface of the papilla summit as separate points. Covering these tips is a thin layer of epithelium, a modified prolongation of the epithelium of the papilla. This structure is evidently normal since no signs of a rupture of the epithelium are found. Toward the tips of these protruding spicules, the covering epithelium becomes reduced to a very thin layer, and the cell nuclei are scattered and much flattened, while near the points of their emergence the epithelium becomes progressively higher and continues with the cuboidal to columnar cells of the papilla. The central portion of the papilla surrounded by the group of spicule apices may be flat or slightly elevated. Its epithelium is columnar, the cells closely crowded, some of which are crowded with acidophile granules. The use of neurofibrillar staining methods, such as that of Cajal and Bielschowski, failed to reveal any special nerve endings, which, however, may be because of the limited material at hand. The general arrangement of the papillae and spicules suggests the nervous apparatus termed caryophyllidia by Labbé (1929) as found by him in *Rostanga coccinea*.

The inner ends of the papillae of *Petelodoris spongicola* interlace with the irregular meshwork of more horizontal spicules which lie below and between the bases of the papillae and which form a part of the general supporting framework of the notaeum. Intermingled with these are numerous single and aggregated rounded calcareous concretions.

The base of each papilla is further marked by the presence of smooth muscle fibers originating from the spicular network and inserted upon the lower parts of the vertical spicules of the papilla. Probably some of these smooth muscle fibers are also inserted in the connective tissue and the basement membrane of the epithelium of the papilla, the whole suggesting a motor mechanism by which the individual papilla may be moved. Nerve fibers may be traced to these groups, but their endings have not been satisfactorily made out.

## Subfamily DISCODORIDINAE

Genus *Anisodoris* BERGH

*Anisodoris* BERGH, 1898. Die Opisthobranchier der Sammlung Plate. Zool. Jahrb., Suppl. Bd. 4, Heft 3 (Fauna Chilensis, Bd. 1, Heft 3), pp. 481-582, pls. 28-33, Dec. 15, 1898.

*Montereina* MACFARLAND, 1905. Prelim. Account of Dorididae of Monterey Bay, California. Proc. Biol. Soc. Washington, vol. 18, p. 38. Type species: *Montereina nobilis* MacFarland. MACFARLAND, 1906. Opisthobranchiate Mollusca from Monterey Bay. Bull. U. S. Bureau of Fisheries, vol. 25, p. 116.

*Body* firm, dorsum tuberculate; tentacles long, conical; branchiae large, tri- or quadripinnate in a few divisions; lips smooth; prostatic gland large, vagina and penis unarmed.

In my preliminary paper of 1905, a new genus, *Montereina*, was proposed for a species which differed strikingly from the other Archidoridinae. The description was written in 1894 as it appeared in the paper cited above. Unfortunately, the important paper of Bergh (1898) upon the Opisthobranchs of Chile based on the Plate Collection was overlooked in which a new genus *Anisodoris* was described with which *Montereina* is almost identical; the slight difference is not sufficient to warrant its retention as a distinct genus and is to be regarded as a synonym of *Anisodoris*.

*Anisodoris nobilis* (MacFarland)

Plate 28, figures 1, 3; plate 29, figures 16, 17; plate 37, figures 22-27

*Montereina nobilis* MACFARLAND, 1905. Preliminary Account of Dorididae of Monterey Bay, California. Proc. Biol. Soc. Washington, vol. 18, pp. 38-39.

*Anisodoris nobilis* (MACFARLAND), 1906. Opisthobranchiate Mollusca from Monterey Bay, California, and Vicinity. Bull. U.S. Bureau of Fisheries, vol. 25, pp. 116-118, pl. 18, figs. 6-11; pl. 22, figs. 1 and 2. O'DONOGHUE, 1921. Nudibranchs of the Vancouver Region. Trans. Roy. Can. Institute, Toronto, vol. 13, pt. 1, pp. 156-158, pl. 1, figs. 9, 10. O'DONOGHUE, 1922. Notes on the Nudibranchiate Mollusca from the Vancouver Island Region, I. Color Variations. Trans. Roy. Can. Institute, Toronto, vol. 14, pt. 1, p. 126. O'DONOGHUE, 1922. Notes, etc. II. The Spawn of Certain Species. Trans. Roy. Can. Institute, Toronto, vol. 14, pt. 1, p. 137. O'DONOGHUE, 1922. Notes, etc. III. Records of Species and Distribution. Trans. Roy. Can. Institute, Toronto, vol. 14, pt. 1, p. 163. O'DONOGHUE, 1924. Notes, etc. IV. Additional Species and Records. Trans. Roy. Can. Institute, Toronto, vol. 15, pt. 1, pp. 1, 22-23, 28-29. O'DONOGHUE, 1926. List of Nudibr. Mollusca recorded from the Pacific Coast of North America. Trans. Roy. Can. Institute, Toronto, vol. 15, pt. 2, p. 207. O'DONOGHUE, 1927. Nudibranchs from Laguna Beach, Calif. Journ. Ent. and Zool., Pomona College, vol. 19, p. 81, pl. 1, figs. 4, 5. JOHNSON and SNOOK, 1927. Seashore Animals of the Pacific Coast. Macmillan Co., New York, pp. 491-492, pl. 8, fig. 3.

*Body* very large, plump, arched, but little depressed; broad elongate-elliptical in outline, the ends nearly equally rounded. Notaeum thickly tuberculate, the tubercles slightly inflated at their distal ends.

The *foot* broad, smooth, abruptly rounded in front, more gradually so behind, its anterior margins bilabiate, the upper lip with a slight median notch. (Pl. 37, fig. 26.)

*Rhinophores* stout, the stalk conical, the clavus perfoliate with about 24 leaves, the sheaths with tuberculate margins.

The *branchial plumes* six, large, spreading, tri- and quadripinnate, covering the entire posterior dorsum.

General *ground color* a rich orange-yellow, varying to a light yellow in some specimens. The dorsum mottled everywhere between the tubercles with irregular blotches of dark brown or black. The total amount of this mottling may vary within wide limits in different individuals. The foot and rhinophore stalk are of the lighter body yellow, the plates of the latter are deep orange, while the branchial plumes are pale, suffused with pink, tipped with white.

*Radula* broad and short, deeply grooved, colorless or nearly so. The rachis is very narrow, naked; the teeth in 26 rows of 55 to 62 teeth on each side, 26 (55-62.0. 55-62). The pleurae are large, strongly hooked, the wing much less strongly developed than in *Archidoris montereyensis*. (Pl. 37, figs. 22, 23, 24, 25.)

*Reproductive system.* (Pl. 37, fig. 27.) The hermaphroditic gland is yellowish, thin, closely investing the liver, and at its anterior upper border giving origin to the short, narrow, straight hermaphroditic duct, 2 mm. long by 0.3 mm. wide, which passes directly forward to the anterior genital mass, dilating into its wide, whitish ampulla, which is closely looped upon the inner anterior face of the mass. The diameter of the hermaphroditic ampulla is 1 mm., its length about 8 mm.

The *anterior genital mass* is large, its outer surface convex, its inner rounded in front and beveled obliquely from within outward behind. At its anterior inner margin the distal end of the hermaphroditic ampulla passes into the substance of the nidamental gland and divides into the spermatic duct and the oviduct. The former duct is short and narrow, passing almost at once into the large, whitish-yellow prostate gland which lies upon the upper surface of the anterior genital mass. It is a large ovoidal body, with smooth outline, about 6 mm. long by 3 mm. in greatest diameter, convex above. From its distal extremity passes the long slender vas deferens, about 22 mm. in length by 0.6 mm. in greatest diameter, convoluted into a number of close loops along the anterior border of the genital mass, and dilating into the thick conical penis (preputium), which is 2.4 mm. wide by 4 mm. long (retracted), with a short, conical, unarmed glans.

The *uterine duct* receives the duct of the spermatocyst a short distance from its point of emergence from the nidamental gland. The spermatocyst is oblong, 1.5 mm. in diameter, with a short duct about as long as the cyst. The large, spherical, gray spermatheca, 5 mm. in diameter, is situated in the posterior half of the anterior genital mass, and receives the oviduct on its lower anterior surface close to the point of origin of the vaginal duct. The latter is about 10 mm. long and 0.3 mm. in diameter, dilating

gradually at its distal end into the unarmed vagina. The nidamental and albumen glands are large, their structure and relations usually as in the Archidoriinae.

*Dimensions.* Length up to 20 cm.; width to 6 cm.; height to 3 cm.

*Habitat.* Found in rocky tide pools all along the coast of Monterey Bay and southward at all seasons of the year but most abundant in the summer. It is found on the piles of the Monterey wharf in company with the preceding smaller species, *Archidoris montereyensis*, from which it may be readily distinguished by the dark blotches of color of the dorsum being distributed between the tubercles and not upon them, and by the conical oral tentacles, as well as by its much larger size. It is the most conspicuous dorid of Monterey Bay.

### Genus *Diaulula* BERGH

*Diaulula* BERGH. 1878. Malacol. Uniers., XIII, p. 567, footnote (*nom. nud.*). BERGH. 1879. Gattungen nordischer Doriden. Archiv f. Naturgesch., Bd. 48, no. 1, pp. 343-344. Genotype, *Diaulula sandiegensis* (Cooper).

### *Diaulula sandiegensis* (Cooper)

Plate 27, figure 6; plate 29, figure 15; plate 30, figure 17; plate 35, figures 23-25

*Doris* (*Actinocyclus*?) *sandiegensis* COOPER. 1862. Proc. Calif. Acad. Nat. Sci., vol. 2, p. 204; 1863, vol. 3, p. 58. (Reprint 1868.)

*Diaulula sandiegensis* (Cooper), BERGH. 1880. Nudibr. Moll. North Pacific Ocean, pt. II. Proc. Acad. Nat. Sci. Philadelphia, vol. 32, pp. 40-46. BERGH. 1894. Bull. Mus. Comp. Zool. Harvard, vol. 25, no. 10, pp. 172-175. MACFARLAND, 1905. Prelim. Acc. Dorididae Monterey Bay. Proc. Biol. Soc. Washington, vol. 18, p. 41.

*Body* somewhat depressed, elliptical, the ends equally rounded, the dorsum very finely villous and velvety. The mantle extends beyond the head and foot except at the tip of the tail when crawling freely, its edges undulating, often thrown into slight folds. In alcoholic specimens it projects widely beyond the sides, 5 mm. to 9 mm. (Pl. 27, fig. 6.)

The *head* is entirely concealed by the mantle, the mouth is a longitudinal slit, the anterior tentacles on either side are digitiform and small.

The *foot* is elongate oval, the ends rounded, the anterior one deeply bilabiate, the upper lamella thinner, broader, and bearing a median notch.

The *rhinophores* conical, the clavus dilated, perfoliate with about twenty to thirty leaves, deeply retractile into a conspicuous flaring sheath with crenulate margin. (Pl. 29, fig. 15.)

*Branchiae* six, deeply retractile, tripinnate plumes inclosing the anal papilla in a nearly complete circle. The margin of the branchial cavity prominent, crenulate. The

plumes are very widely spreading and large, in some specimens covering the entire posterior part of the dorsum.

The *anal* papilla is large and prominent, the inconspicuous renal pore close in front to the right of it.

In one alcoholic specimen the reproductive opening is 13.5 mm. posterior to the anterior notaeum margin on the right side.

*Labial cuticula* is simple, smooth. The pharyngeal bulb is not large and the radula sheath is very prominent on the lower hinder margin.

*Radula* rather broad, of square shape, about twice as long as wide, in the anterior portion, yellow. Rachis of the radula is broad, naked, the pleural teeth in 19-22 transverse rows with from 26-30 teeth in each half row, the dental formula being 19-22 (26-30.0.26-30). The pleural teeth strongly hooked, compressed, the innermost smaller than those following, the outermost also much reduced in size. (Pl. 35, figs. 23, 24.) Upon the inner side of each tooth exists a narrow, wing-like expansion, decreasing as a thickening along the back toward the tip. (Pl. 35, fig. 24.)

The general *body color* is yellow ochre to raw umber which varies from a light shade to a deep brown of chocolate hue. The dorsum is marked by brown to very dark brown rings of varying size, number, and position. In general these rings are arranged in two longitudinal series on each side of the median line, three to four in each row, but this is subject to much variation. The number may be increased to twenty to thirty irregularly scattered ring-like blotches. In some darker specimens rings and spots may appear along the mid-line of the body and in the peripheral zone around the entire notaeum. In some instances the rings are bounded by a light zone. These variations are found especially in a collection from British Columbian waters made by E. F. Ricketts in 1946 and kindly turned over to me by him.

*Dimensions.* The largest living specimen recorded was taken from Elkhorn Slough, Monterey Bay, by G. E. MacGinitie, 1942. (Pl. 30, fig. 17.) Length 80 mm. by 45 mm. in width, with a gill spread of 45 mm. The largest ring on dorsum 10 mm. in diameter. Smallest specimen collected was 7.5 mm. in length with six small dark spots on the dorsum in two rows. In July a second large specimen was collected by Rolf L. Bolin from Elkhorn Slough, with many large ringed spots.

Largest preserved specimen from shore collecting at Pacific Grove, length over all along curvature of back 57 mm., horizontal length 50 mm., maximum breadth 28 mm., thickness 14 mm. Anterior margin of notum to anterior margin of branchial cavity 39 mm., length of branchial cavity 6 mm.; posterior branchial cavity margin to end of notum 12 mm. Post-branchial notum is one-fifth of total length. Maximum width of mantle margin 9.2 mm. Foot length 37 mm., maximum width 15 mm.

*Habitat.* In rocky tide pools of the furoid zone of the coast of Monterey Bay. It is not abundant but has been taken during the entire year. The species has a wide range extending north to Sitka and Unalaska, Alaska.

### Genus *Discodoris* BERGH

*Discodoris* BERGH, 1877. Jahrbücher d. deutschen Malacozoologischen Gesellschaft, Jahrg. 4, p. 61.  
MACFARLAND, 1906. Opisthobranchiate Mollusca from Monterey Bay, California, and Vicinity.  
Bull. U. S. Bureau of Fisheries, vol. 25, p. 118.

### *Discodoris heathi* MacFarland

Plate 27, figure 7; plate 35, figures 26-33

*Discodoris heathi* MACFARLAND, 1905. Prelim. Account of Dorididae of Monterey Bay, California. Proc. Biol. Soc. Washington, vol. 18, pp. 39-40. MACFARLAND, 1906. Opisthobranchiate Mollusca from Monterey Bay, California and Vicinity. Bull. U.S. Bureau of Fisheries, vol. 25, pp. 118-119, pl. 18, figs. 12-17; pl. 23, fig. 6. O'DONOGHUE, 1922. Notes on the Nudibranchiate Mollusca from the Vancouver Island Region. III. Records of Species and Distribution. Trans. Roy. Can. Institute, Toronto, vol. 14, pt. 1, pp. 151-152, pl. 5, figs. 8-11. O'DONOGHUE, 1926. List of Nudibranchiate Mollusca recorded from the Pacific Coast of North America. Trans. Roy. Can. Institute, Toronto, vol. 15, pt. 2, p. 207. O'DONOGHUE, 1927. Notes on a collection of Nudibranchs from Laguna Beach, California. Journ. Ent. and Zool., Pomona College, vol. 19, p. 82, pl. 1, figs. 6-9.

*Body* elliptical, broad, depressed, dorsum minutely tuberculate, nearly smooth. Mantle margin thin, wide, crenulate, extending far beyond the foot except behind.

*Foot* rather narrow, its anterior end abruptly rounded, bilabiate; the upper lip deeply notched.

The *head* is small and inconspicuous, being almost concealed between the mantle and foot. Oral tentacles are long, cylindro-conical. (Pl. 35, fig. 26.)

*Rhinophores* moderately large, clavus perfoliate with ten to fifteen leaves, the whole organ retractile into a low sheath with slightly sinuous margin.

The *branchiae* are in eight to ten divisions, tripinnate, small, spreading.

*Labial disk* elliptical, convex, the labial armature of short, closely set rods about  $42\mu$  long by  $3.5\mu$  in diameter arranged in two yellowish lateral lamellae nearly quadrangular in form on the upper half of the tube; *radula* colorless, twice as long as broad, not deeply grooved, the teeth in twenty rows of thirty-six to forty-two teeth in each half row; rachis naked, pleurae strongly hooked, the innermost ten to twenty-five in each row nearly equal in size, the hook slightly increasing in length, the shaft obliquely curved toward the median line and bearing a thin wing-like expansion on the inner side. The outermost twelve to sixteen pleurae decrease very rapidly in size, fit closely together and become reduced to thin concave plates. (Pl. 35, figs. 27, 28.)



The *hermaphroditic duct* emerges from the visceral mass and dilates almost immediately into its ampulla, then courses forward along to the anterior face of the genital mass where it narrows, gives off the spermatic duct, and passes on as oviduct.

*Glans penis* is bluntly conical, short, unarmed; the vas deferens very long and narrow passing into the thick prostate gland. (Pl. 35, fig. 33.)

The small *spermatocyst* is oval in shape, its duct quite short and opening into the uterine duct.

The *spermatheca* is large, its two ducts join it close together, the vaginal duct passing straight outward and dilating into the vagina. (Pl. 35, fig. 32.)

A *vestibular gland* is present and opens into the vestibulum close to the vagina.

The general *body color* is light yellow, ochre to raw umber, becoming darker toward the median line. The dorsum is sprinkled everywhere with extremely minute brown to black spots, giving the animal a general dusty appearance; a variable number of very dark-brown to red-brown flecks are scattered irregularly over the dorsum, the majority in the mid-region. The foot, the rhinophore stalks, and branchial plumes are of the lighter yellow shade. The plates of the clavus a brown color, these and the branchiae are sprinkled with minute dark-brown spots.

*Dimensions.* Average specifications 30 mm. long, 15 mm. wide, 6 mm. high.

*Habitat.* In rocky tide-pools from Point Pinos to Monterey, rather rare. Usually most easily found during July and August, but has been taken during the winter months as well. In July of 1919 it was abundant and laying.

The species name is given in honor of Dr. Harold Heath, professor of Zoology at Stanford University, who has done excellent work upon the Mollusca and to whose willing cooperation the author owes much assistance in collecting Pacific coast nudibranchs.

### Subfamily DENDRODORIDINAE

#### Genus *Dendrodoris* EHRENBURG

*Dendrodoris* EHRENBURG, 1831. *Symbolae Physicae*, I, Text, p. 94 (plates published in 1828).

*Doridopsis* ALDER and HANCOCK. 1864. *Trans. Zool. Soc. London*, vol. 3, pp. 124-130, pl. 31. HANCOCK, 1865. On the Anatomy of *Doridopsis*. *Trans. Linnean Soc. London*, vol. 25, pp. 189-207, pls. 16-20. PRUVOT-FOL, 1930. Du genre *Dendrodoris* Ehrenberg, et de ses rapports avec le genre *Doridopsis* Pease et avec quelques autres. *Bull. Mus. Nat. d'Hist. Nat., Paris*, ser. 2, vol. 2, no. 3, pp. 291-297.

The genus *Dendrodoris* Ehrenberg, 1831, is based upon the species *D. lugubris* described in an incomplete fashion as judged by present standards, but adequate for its recognition. In 1864, Alder and Hancock described the new genus *Doridopsis*, giving considerable anatomical detail, which was extended by Hancock in 1865, based chiefly

upon *Doridopsis gemmacea* Alder and Hancock, although nine other species are listed in the paper, *D. gemmacea* being third. These, and the later papers of Bergh, give very satisfactory information concerning the genus. Bergh, however, ignored the priority of Ehrenberg's name *Dendrodoris* and substituted for it not *Doridopsis* of Alder and Hancock, 1864, but *Doriopsis* Pease, 1860, based upon *Doriopsis granulosa* Pease from "Sandwich Islands" [Hawaiian Islands]. Bergh assumed that Pease in 1871 considered *Doridopsis* Alder and Hancock as identical with his own earlier *Doriopsis*, when in fact he did nothing of the sort, but suggested the new name *Haustellodoris* to replace the name of Alder and Hancock for their genus, their name of 1864 being preoccupied by his of 1860. Despite this fact, Bergh continued his use of the name *Doriopsis* Pease for the genus and for the family Doriopsidae, and the weight of his great authority caused other writers to do the same. Mme. Pruvot-Fol (1930) called attention to this error in a clear analysis of the facts in the cases which would seem to definitely settle the matter. According to her, *Doriopsis* Pease, 1860, is a valid and different genus of Dorididae, having as synonyms *Staurodoris* Eliot, *Ctenodoris* Eliot, 1907, and *Guyonia* Risbec, 1927.

While the general external appearance of *Dendrodoris* is similar to that of Dorididae in general, the wide undulating mantle margin, the pore-like mouth opening, and the rudimentary, adnate oral tentacles, and usually, the location of the branchial pocket far back on the notum, clearly indicate its differences, while the simplest anatomical examination will reveal the total absence of mandibular plates and radula and the reduction of the pharyngeal bulb to a muscular tube.

### ***Dendrodoris fulva* (MacFarland)**

Plate 28, figure 2; plate 29, figures 18, 19

*Doriopsis fulva* MACFARLAND, 1905. Proc. Biol. Soc. Washington, vol. 18, p. 45. MACFARLAND, 1906. Bulletin U.S. Bureau of Fisheries, vol. 25, pp. 130-131, pl. 22, fig. 3; pl. 19, figs. 38-40. GUERNSEY, 1912. First Annual Report Laguna Marine Lab., p. 77, fig. 38 B. O'DONOGHUE, 1922. Proc. Malacol. Soc. London, vol. 15, pt. 5, pp. 142-144. O'DONOGHUE, 1927. Nudibr. Laguna Beach. Journ. Ent. Zool., Pomona College, vol. 19, pp. 92-93. JOHNSON and SNOOK, 1927. Seashore Animals of the Pacific Coast, p. 498, pl. 11, fig. 5.

The most striking anatomical characteristic in this species, as in the genus, is the modification of the usual pharyngeal bulb into a sucking tube with a complete absence of anything resembling a labial or mandibular armature and a radula.

*Body* elongate, elliptical, somewhat depressed, the mantle equally rounded in front and behind, the dorsum soft, with low papilla-like elevations nearly all of which bear a small, central, white fleck.

*Mantle* margin thin, wide, undulating, extending well beyond the foot, its ventral surface showing a fine, reticulate system of narrow whitish lines, the meshes coarser near the body and becoming smaller toward the edge.

*Foot* elongate, elliptical, the anterior and posterior ends nearly equally rounded, the tail projecting but slightly beyond the mantle behind, the anterior margin bilabiate, the upper lip with a deep median notch, the lower lip fleshy, the lateral edge of the foot thin.

*Reproductive openings* in the usual position well forward on the right side upon a prominent rounded papilla.

*Mouth opening* very small, pore-like, entirely concealed between mantle and foot.

*Tentacles* rudimentary, very short and flattened, adnate to the under surface of the mantle, close together and directed forward.

*Rhinophores* not large, cylindro-conical, inclined forward and outward, the conical clavus slightly dilated, the tip blunt, perfoliate with about 20 leaves, the stalk cylindrical, smooth, one-third the length of the whole organ. Rhinophores completely retractile within conspicuous sheaths with low, smooth, thin margins. Length of clavus 4 mm.; of whole rhinophore 6-7 mm.; height of sheath 0.7 mm. (not 7 mm. as given erroneously in MacFarland, 1896, p. 130). (Pl. 29, figs. 18, 19.)

*Branchial plumes* five, tripinnate, wide-spreading, arranged in a circle, deeply retractile within a sheath with high, thin, flaring margin, its edge smooth, its outer surface covered with low, small tubercles similar to those of the dorsum. Height of sheath 2 mm., its diameter 6 mm. Anal papilla at right of center of circle of branchiae, bluntly conical. Renal opening inconspicuous, at base of and slightly in front of anal papilla.

The general *color* is a rich yellow-orange. The foot, rhinophore stalks, and branchiae are much paler, the latter showing some white on the finer divisions. Rhinophore plates brown. The papilla-like elevations usually bear a central white fleck.

*Dimensions* of large specimen, length 65 mm., breadth 30 mm., height 12-13 mm., width of mantle margin 8 mm.

*Habitat.* *Dendrodoris fulva* is one of the commonest nudibranchs to be found in the Monterey Bay region, occurring in the tide pools all along the coast at all times of the year, but most abundantly during the summer months. It has also been recorded from Newport Bay, Laguna, and San Diego, and probably will be found at many intermediate points. Its egg bands are in the form of a long, narrow, yellow ribbon about 7 mm. in width, closely coiled in a spiral and fastened to rocks or brown algae. It is also deposited abundantly in the aquarium in which the animals may be kept for some time. Egg laying is most abundant during the summer months, but may also occur at any time during the year. Four specimens taken on upper Newport Bay in April, 1946, showed a singular appearance of detachment of epidermis in patches with abundant protozoa and bacteria beneath and around the patches as seen through the microscope. Three specimens were taken December 30, 1929. The smallest specimen shows, in addition to the usual white sprinkling, three pairs of small, obscure, yellowish brown rings

arranged on either side of the median line and spaced nearly equally between rhinophores and branchiae, as in *Diaulula*.

### *Dendrodoris albopunctata* (Cooper)

Plate 28, figure 4

*Doris albopunctata* COOPER, 1863. On New or Rare Mollusca Inhabiting the Coast of California, No. II. Proc. Calif. Acad. Nat. Sci., vol. 3, p. 58.

*Doridopsis reticulata* COCKERELL and ELIOT, 1905. Notes on a Collection of California Nudibranchs. Journ. Malacol., vol. 12, pp. 41-42, pl. 7, fig. 5.

*Doriopsilla reticulata*, ELIOT, 1906. Proc. Zool. Soc. London, p. 665.

*Doris* sp., GUERNSEY, 1912. Some of the Mollusca of Laguna Beach. First Annual Report Laguna Marine Laboratory, p. 78, fig. 38 C.

*Doriopsilla albopunctata*, O'DONOGHUE, 1922. Notes on the Taxonomy of Nudibranchiate Mollusca from the Pacific Coast of North America. Proc. Malacol. Soc. London, vol. 15, pp. 142-144. O'DONOGHUE, 1926. A List of the Nudibranchiate Mollusca recorded from the Pacific Coast of North America, with Notes on their Distribution. Trans. Roy. Can. Inst., Toronto, vol. 15, pt. 2, p. 205. O'DONOGHUE, 1927. Notes on a Collection of Nudibranchs from Laguna Beach, California. Journ. Entomol. and Zool., Pomona College, vol. 19, pp. 93-95.

In 1863 J. G. Cooper described, in the second of his pioneer papers upon the nudibranchiate mollusks of California, *Doris albopunctata* as follows:

"Form ovate, pointed behind, flattened, surface shining, minutely rugose. Tentacles club-shaped, retractile, branchial plume, 6-8 parted, bipinnately divided, situated near the posterior extremity. Color yellow or orange brown, dorsal surface thickly speckled with small white dots, each forming a slightly raised papilla. Beneath paler.

"Dredged from a rocky bottom in twenty fathoms, a mile from the shore at Santa Barbara. Also found on rocks at low water mark near the north-west end of Catalina Island.

"Length about one inch, breadth one-third of an inch."

The general color is a pale yellow-orange to orange, the dorsum center being much darker, raw umber in color.

The rhinophore stalks and gill plumes are clear and translucent, their sheaths yellow, rhinophore plates a deeper yellow-orange. The ventral surface of the foot light yellow. Each low rounded papilla of the dorsum is tipped with white, these spots being larger and numerous in the central dark area, but small and sparse as the margin is reached.

*Dimensions.* Length 17 mm., width 19.5 mm., foot length 14.2 mm., 5.2 mm. wide, rhinophores 2.5 mm. high, diameter of stalk at the base 1 mm., rhinophores to anterior margin 2.3 mm., span between them 1.5 mm., distance posterior to gill margin 9 mm., posterior gill margin to mantle edge 2 mm. The Corona del Mar specimens were wider in proportion than the La Jolla specimen.

*Habitat.* Dredged off Santa Barbara. Taken at Catalina Island and in rocky pools at La Jolla and Corona del Mar.

## Superfamily ARMINACEA

### Family ARMINIDAE

#### Genus *Armina* RAFINESQUE

*Armina* RAFINESQUE, 1814. Précis des Découvertes Somnologiques ou Zoologiques et Botaniques, Palermo, p. 30. RAFINESQUE, 1815. Analyse de la Nature, ou Tableau de l'Univers et des Corps Organisés, Palermo, p. 15 (142).

*Pleurophyllidia* MECKEL, 1816. In Stammer, Observations ex Anatomia comparata Halae, p. 22. MECKEL, 1823. Beschreibung einer neuen Mollusk. Deutsches Archiv für die Physiologie, vol. 8, pp. 190-207 (197), pl. 2, figs. 1-7. MECKEL, 1826. Archiv für Anatomie und Physiologie, vol. 1, pp. 18-19, pl. 1, figs. 11-14.

*Diphyllidia* BLAINVILLE, 1819. Dict. Sci. Nat., vol. 13, p. 299. Cuvier Ms.

*Linguella* BLAINVILLE, 1825. Manuel de Malacologie et de Conchyliologie, p. 491, pl. 47, fig. 2.

*Body* elongate or oval, somewhat depressed or slightly arched. Head short, wide, separated above from the mantle, below continuous with the sole. Tentacular clypeus transverse, reniform or oval in shape, free at posterior margin, and produced into short, rounded, tentacle-like angles, rhinophores contiguous, in front of pallial margin, in front of them a more or less developed muchal caruncle. Paired lamelliform branchiae borne on under surface of mantle in front, behind them more irregular ridge-like lamellae. Mantle margin with numerous thickset cnidosacs.

#### Subgenus *Armina* RAFINESQUE

Between the head shield and the rhinophores there is either a fold or a few caruncle ridges; border of the notaeum continuous behind the closely contiguous rhinophores. Back with elevated longitudinal lines or with tubercles. Ex. *A. tigrina* Rafinesque.

The original fragmentary description of Rafinesque reads as follows:

P. 30 "XXI. G. ARMINA. Corps oblong déprimé, bouche nue retractile, flancs lamelleux, annus à la droite.—Même famille du précédent (i. e. Phyllidia).

[Under this new genus he lists two new species, presumably from Sicilian waters.]

"79. *Armina maculata*. Dos roussâtre taché de blanc, deux petits tentacules obovés sur la tête, corps aigu postérieurement.

"80. *Armina tigrina*. Dos noirâtre, varié de lignes ondulées blanches, point de tentacules, corps obtus postérieurement."

Two years later J. F. Meckel (1816) described in a thesis of one of his students, Stammer, the new genus *Pleurophyllidia* with the type species *Pl. undulata* from material collected at Naples. The name Stammer has been variously quoted as Stammer, Hammer, and Stirner, and the publication was virtually buried. In 1817 the genus



*Diphyllidia* Cuvier was established in the Règne Animal, first edition, volume 2, p. 395, for a form clearly congeneric with *Pleurophyllidia* and *Armina*.

In 1823 Meckel reprinted his earlier diagnosis (1816) of the genus and the type species, adding to it some anatomical details which were supplemented in his paper of 1826. Rang's Manual (1829) lists *Armina* Rafinesque as a questionable synonym of *Diphyllidia* Cuvier but states that it is probably the same, nevertheless using the later Cuvierian name. Souleyet (1852) called attention to the priority of Rafinesque's name and Bergh (1866, p. 2; 1869, p. 222) concludes that the genera are very probably identical, but owing to the vagueness of Rafinesque's characters, he prefers to disregard the name *Armina*, preferring *Pleurophyllidia* Meckel instead. While the description is undoubtedly too brief, as judged by modern standards, there is no doubt but that he was dealing with the same genus as Meckel and Cuvier, and Bergh himself did not hesitate to list Rafinesque's two species, *A. maculata* and *A. tigrina*, as synonymous with *Pleurophyllidia undulata* (Meckel) and *Pleurophyllidia pustulosa* (Schultz) of Phillipi and Stammer respectively.

This arrangement should be reversed since Rafinesque's two species have priority. Iredale and O'Donoghue (1923, p. 217) replace *Armina* Rafinesque, 1814, as the name of the genus and designate *A. tigrina* Rafinesque as the type species, although *A. maculata* is given first by Rafinesque.

The earliest papers of Bergh were chiefly devoted to this group and his anatomical studies greatly extended the earlier ones of Meckel, delle Chiaje, and Souleyet.

### *Armina californica* (Cooper)

Plate 38, figures 1-6; plate 43, figures 37-44; plate 44, figures 6, 7

*Pleurophyllidia californica* COOPER, 1862. Proc. Calif. Acad. Nat. Sci., vol. 2, pp. 203-204. San Diego Bay. BERGH, 1890. Weitere Beiträge zur Kenntnis der Pleurophyllidien. Verh. k. k. Zool. - Bot. Ges. Wien, vol. 40, pp. 3-8, pl. 1, figs. 1-16; pl. 2, figs. 1-2. Berlin Museum, collected by Forrer "Coast of California." BERGH, 1894. Die Opisthobranchien. Bull. Mus. Comp. Zool. Harvard, vol. 25, no. 10, pp. 154-157, pl. 3, figs. 14-15; pl. 4, figs. 7-12. Eight specimens collected by the U.S.S. *Albatross*; Gulf of California, Pequeña Bay. O'DONOGHUE, 1921. Nudibranchiate Mollusca from the Vancouver Island Region. Trans. Roy. Can. Inst., Toronto, vol. 13, pt. 1, pp. 178-180. O'DONOGHUE, 1922. Notes on Nudibranchiate Mollusca from the Vancouver Island Region. Trans. Roy. Can. Inst., Toronto, vol. 14, pt. 1, p. 124. O'DONOGHUE, 1926. Studies from the Biological Stations. Trans. Roy. Can. Inst., Toronto, vol. 15, pt. 2, p. 222.

*Body* (Monterey Bay specimen) ovate, rounded in front, tapering behind to a pointed tail, highest in front and sloping gently backward.

*Head* expanded in front into a transverse frontal shield with undulating margins and with free bluntly pointed lateral angles. Mantle margin projecting beyond the sides of the body laterally, in front carried across above the head leaving a deep transverse groove between it and the posterior margin of the cephalic shield, behind free from the foot tip. (Pl. 38, figs. 1, 2, 4.)



*Mantle* margin with a median rounded notch in front, within which the closely approximated rhinophores appear. In front of the rhinophores there is a slight roughening of the median surface, but no prominent caruncle such as is frequently found in other species.

*Rhinophores* (pl. 38, fig. 4) short, blunt, closely approximated, the bases nearly united. Each rhinophore consists of a short, stout, semicylindrical stalk, flattened medially and rounded externally, which swells above into an ovoid head, similarly flattened within and rounded without.

The *clavus* is divided longitudinally by a number of deep grooves into thick flattened vertical plates, which are in turn split into secondary plates by vertical furrows but not so deeply as the primary ones.

Near the undivided apex of the rhinophore the primary divisions appear; in the lower half of the clavus the secondary ones are formed somewhat irregularly, so that the full number, 30 to 40, is found in that region. (Pl. 38, fig. 5.)

The rhinophores are retractile between the anterior margin of the mantle and the posterior margin of the clypeus. Below this they retire into a common cavity with low margins, at the bottom of which a division into separate cavities obtains. Complete retraction of the rhinophores within these last cavities is not common. They are controlled by strong retractor muscles which draw them down behind the fold in front and the mantle marginal notch behind and into a scarcely defined sheath surrounding each. When in a state of complete expansion, the margin of the upper common sheath may be obliterated.

At the base of the rhinophores the *eyes* show through the integument.

Around the under side of the *mantle* is a submarginal, somewhat thickened zone bearing a single row of pustule-like elevations with central apertures opening into cnidosacs. This series extends along the sides of the mantle margin from about opposite the lateral tips of the cephalic shield backward to a short distance in front of the tip of the tail. (Pl. 38, fig. 2.)

The ventral surface of the mantle margin bears a closely set series of some 15 to 30 thickened oblique ridges, about 0.8 mm. in height, beginning immediately behind the gills and extending back to a short distance in front of the tip of the dorsum. The most of these run uninterruptedly from near the body wall outward toward the margin, terminating before reaching it. Between these main ridges, other shorter ones may be interpolated, usually toward the margin. The most anterior two or three of these subpallial ridges are frequently continuous, by a low thinner ridge, with a similar number of the thin branchial lamellae, in parallel longitudinal arrangement. The longest of these ridges may reach a length of 6 to 8 mm. in length at the anterior end of the series.

The anterior branchial lamellae slope rapidly downward in front to the mantle surface; behind they terminate abruptly in a rounded lobe. These may be regarded as the actual respiratory organs aside from the general integument. They are alternately high and low. Some 30 or more may be readily counted with the unaided eye or with a

simple lens, and serial sections reveal additional smaller ones to a total of about 60. Each plate consists externally of a low columnar epithelium resting upon a slight framework of connective tissue supporting an elaborate network of vascular spaces. Beneath the epithelium a thin layer of muscle fiber occurs, mainly at right angles to the length of the lamella.

Above the bases of these lamellae the branches of the anterior part of the liver ramify, but none of its tubules extend down into the lamellae. However, in the posterior subpallial ridges, commonly termed gills, also is found a terminal branching of the liver to such an extent that the ridges are nearly filled, the vascular channels being proportionately much less extensive and evidently tributary to the liver primarily.

O'Donoghue (1921, p. 180) states, "The branchiae lie on the under surface of the mantle forming a series of about 20 large and some smaller obliquely transverse gill plates. Each plate bears a series of about 30 thick side lamellae." No mention is made of the anterior group of thin lamellae on either side. In all my specimens each of the ridges, while undulating, is entirely destitute of anything resembling "a series of about 30 thick side lamellae" and I am at a loss to interpret his meaning.

*Foot* broad and flat, smooth, rounded in front, tapering behind to tip of tail, anterior margin thickened, carried back laterally opposite the anterior ends of the gill lamellae where it terminates in an inconspicuous rounded angle. Hinder end with a shallow median longitudinal groove marking the position of numerous pedal glands.

*Mouth* a small transverse oval aperture between the medial foot margin and the lower edge of the cephalic shield, its lips scarcely inflated, wrinkled.

*Anus* at the summit of a truncate conical papilla on the right side at about two-thirds the body length from the anterior end.

*Reproductive openings* on the right side below the posterior end of the gill lamellae group. Renal opening an inconspicuous pore midway between the reproductive and anal openings on the right side and slightly above their level.

*Color.* General ground color of the dorsum is a light pinkish brown (indian red and bismarck brown) through intermediate shades to dark brown or black, relieved by low, elevated, undulating, longitudinal ridges of white arising in front at the anterior margin and diverging slightly as they pass back, ending at intervals along the posterior margin of the mantle.

Of these lines, a single median and two lateral ones on either side originate from the margin of the anterior notch and pass backward continuously, becoming slightly wider behind. Lateral to the median notch some five to eight similar lines arise from the anterior margin and pass backward, diverging slightly and terminating at intervals along the posterior lateral margins of the mantle. (Pl. 38, fig. 3.)

Alternating with the innermost of these primary lines are three to four secondary ones, appearing faintly at about one-fifth the length of the dorsum and becoming stronger behind. A tertiary series of lines, about four in number on each side of the median

line, appears in the posterior third of the dorsum, alternating with the primary and secondary lines nearest the median, likewise increasing in strength as they pass backward to a similar termination.

In some large specimens a fourth series of similar lines may appear near the hinder end of the body, likewise in the median area. Also the intercalated shorter lines may appear between the more lateral primary ones, but they are not so frequent and are often broken or indistinct.

Occasional forking of the lines may be noticed, but it is neither uniform nor common. In figure 3 of plate 38 a diagram showing the fundamental plan of these markings is given.

The margin of the mantle is edged with cream-white throughout its whole extent. The head shield is edged with the same cream-white, its ground color being a lighter shade of the pinkish brown of the dorsum. The dorsal surface of the cephalic shield presents a deeply pigmented surface, dark brown to black, paralleling the marginal white band in front and mesially extending back to the rhinophores where it forms a low transverse rampart in front of them which becomes lower as it continues outward toward the tips of the clypeus. The triangular surface so limited is rather thickly set with colored papillae. The tips of the rhinophores are white, which color is continued down the clavus upon the margins of the plates. The grooves between the plates and their stalks are grayish and sprinkled with greenish brown or greenish black, becoming less evident below. (Pl. 38, figs. 5, 6.) The sides of the body and the foot are clear translucent fawn, the foot being narrowly edged with white. The branchial lamellae are slightly darker than the general ground color surrounding them.

A roomy *mouth* tube exists in front of the mandibles. The pharyngeal bulb is 6 mm. wide, 7.3 mm. long, and 4.2 mm. high, broadly oval in outline from above, somewhat flattened. The ventro-lateral retractors, nearly meeting in the front, diverge to the sides of the body opposite the posterior end of the bulb.

Two large, ventral, anterior *salivary glands* are exposed beneath and behind the posterior end of the bulb, their slender ducts passing straight forward beneath the bulb and converging to the anterior end of the mouth tube. The gland body is delicate with irregular branched lobulations suspended in connective tissue back of the bulb and in front of the adnexed genital mass. Resting upon the bulb is the lower portion of the dorsal, posterior, salivary gland, slightly darker in color and larger. The two salivary glands are entirely separate, the oesophagus lying between them.

The united *mandibles*, light yellow in color and deeper yellow at the margin, are somewhat basin-shaped and moderately concave behind, the length and the width nearly the same, the width of the single mandible one-half its length. (Pl. 43, figs. 37, 38.) Hinge region slightly crescentic, upper older portion of masticatory margin worn, the lower half less so, prolonged below into a moderate masticatory process, its tip extending as far back as the edge of the mandibles and separated from them by a deep rounded bay. The intact masticatory margin and its process bear an armature of low

flattened spines with slightly elevated, irregularly serrate or pointed margins directed toward the free edge. The outermost three or four rows have fairly prominent free cutting margins. Inwardly they are replaced by three or four rows of flattened pavement-like plates of rectangular outlines becoming shorter and smaller in the innermost rows. Length of typical element near margin 0.03 mm., width 0.015 mm. (Pl. 43, figs. 38, 39.)

The *radula* is pale yellow, broad, the anterior end pointed owing to wear, the remainder rectangular in outline.

In the five specimens examined, ranging in length from 18.4 mm. to 50 mm. in the preserved state, the number of rows of teeth ranges from 30 to 52, the maximum formula ranging from 30 (45.1.45) to 52 (81.1.81).

The median tooth has a broad rectangular base, its anterior margin is convex laterally with a median concavity, the posterior border is slightly concave except in the center below the cusp where it is convex, and the outer angles are pointed and prominent. Upon the strong and wide median cusp are borne two lateral denticles, one on either side of its basal portion, the dorsal anterior surface of the median cusp bears a groove which deepens as it continues forward and downward into the anterior median sulcus of the base. Lateral to the median cusp are from three to five short stout denticles, their tips not reaching the plane of the posterior base line. (Pl. 43, fig. 40.)

The base of the first lateral is squarish and much broader than that of the remaining laterals. From it arises a short stout hook slightly inclined toward the median line. In some cases the outer margin of the hook may be finely serrulate, or may bear one or more small basal denticles or in others may be nearly smooth. The anterior dorsal face of the hook is grooved vertically near its basal portion, the groove merging below into a wide notch which tends to divide the base into an inner and an outer wing-like foot, thicker than the adjacent portion of the base. The inner portion may appear as a rounded lobe projecting freely from the base as in plate 43, figures 40, 41.

The remaining lateral teeth are all of a similar hooked type. From a compressed oval base arises a tall compressed hook. The base uniformly bears a slender spur-like process directed obliquely inward and forward. The hook typically presents a slender acicular denticle on its outer margin below the apex. (Pl. 43, fig. 42.) The second, third, and fourth laterals may lack this denticle, or it may be present as a rudiment, or of smaller size than the others. Similarly it may be wanting in the outermost three to six or more teeth of the row, which also decrease rapidly in size. While the great majority of the laterals possess a single external denticle, variations are not rare. (Pl. 43, fig. 44.) The denticle may be forked at its tip or more extensively downward. One or more minor denticles may appear below it or a minute serrulation may replace it entirely. Such variations are most common toward the outer end of the rows. (Pl. 43, fig. 43.)

Sometimes a giant lateral may be found, evidently produced by the fusion of two or even three teeth, its composite nature being shown by the complex division at the tips. Such anomalies are usually repeated at the same point in successive rows.

*Dimensions* (living animal). Smallest specimen length 18.4 mm., maximum

width 5.9 mm., maximum height 3.6 mm. Largest specimen, length 51 mm., maximum width 20.5 mm., maximum height 11.2 mm. As is the case with most nudibranchs, measurements of the preserved specimens give only an approximate idea of the dimensions of the fully extended living animal, the amount of contraction varying within wide limits, the specimen frequently losing as much as a third or more of its length. But since most studies can be made upon museum material only, such measurements have a definite value.

*Habitat.* Three specimens were taken by dredging on sandy bottom in Monterey Bay in depths of 10 to 15 fathoms. Two specimens dredged by the U.S.S. *Albatross* were also examined, one from a depth of 43-34 fathoms off Point Pinos, another from 26 fathoms off Santa Cruz. Twenty-two specimens from San Diego were collected by Dr. Myrtle Johnson and Dr. Fred Baker, one by F. W. Weymouth, where they are found in the shallow water of Mission Bay. One was dredged by E. C. Starks near San Juan Island, Puget Sound.

The species was originally recorded by Cooper (1862) from San Diego. It has been taken from as far south as the Bay of Panama (*Albatross*, 16 fathoms), from near the lower west coast of the Gulf of California (*Albatross*, 48 fathoms from Pequena Bay), from the Oregon coast (Bergh, 1904, p. 19), and from the Vancouver Island region in 15 to 35 fathoms (O'Donoghue, 1921, p. 178).

It appears to frequent sandy bottoms. In captivity, when given the opportunity, it burrows beneath the surface of the sand leaving the tips of the rhinophores visible. The edges of the mantle are turned downward in contact with the edges of the foot on the sides and in front with the margin of the cephalic shield, thus leaving a channel for the water which bathes the gills and a wide aperture surrounding the rhinophores through which the water is kept in circulation. According to Johnson and Snook (1927, p. 498) it readily devours *Renilla amethystina* Verrill when placed in the same aquarium.

The only record of its egg laying is given by the writer (MacFarland, 1897, *Cellulär Studien Pleurophyllidia*, p. 230). The nidosome was in the form of a light pink-brown, spirally wound, convoluted chain of capsules, each containing from 3 to 22 eggs, fastened upon the glass wall of the aquarium. The cytological changes during fertilization were described in the same paper. Other than this, nothing has been recorded concerning the development of this form.

#### EXTENDED ANATOMICAL DESCRIPTION.

*Alimentary system.* The oesophagus immediately behind the pharyngeal bulb is 1.0 mm. in diameter. At once it dilates slightly and passes straight backward with a diameter of 1.5 mm.; 5.5 mm. behind the posterior margin of the bulb a slender branch is given off to the wall on the right side, 1.5 mm. behind it the intestine is given off on the right side curving backward to the body wall along which it runs to the anal opening.

The intestine, from origin to anus in a straight line, is 12.5 mm. in length. The remaining portion of the alimentary canal passes backward almost straight to the end



of the body cavity, the anterior end of the ovotestis being encircled by it on the left and by the intestine on the right.

A specimen from San Diego, 38 mm. long, 15 mm. wide, 8.5 mm. high, was used for dissection; opened on mid-dorsum.

The liver branches reach the dorsal subintegument about one-half the distance from the median line to the mantle margin and ramify in a close mass of short tubules in the loose connective tissue beneath the integument. At the margin they do not extend in between the cnidosacs nor unite with them but leave their zone free from liver ramifications. The liver branches thus form a longitudinal pad on either side, extending forward as far as the middle of the pharyngeal bulb, and back almost as far as the tip of the tail, extending into the mantle margin.

Posteriorly this median biliary sac dilates to a maximum of 3.3 mm. in diameter, giving off a series of branches on each side to the dorso-lateral body wall where each ramifies. On the left side the most anterior branch is 1.5 mm. posterior to the origin of the intestine, and reaches the body wall behind the region of the left gills. The remaining nine branches come off at successively closer intervals as the posterior end is approached. Ten branches are also present on the right side, the second and third being in front of the anus, the fourth nearly above it, and the remainder behind it.

*Reproductive system.* The ovotestis lies in the middle of the body cavity behind the pericardium and reaches well back toward the tip of the tail. It is composed of a double series of rounded lobes, slightly bent to the right at the anterior end, lying above the stomach and entirely independent of the liver. (Pl. 44, figs. 6, 7.)

The hermaphroditic duct runs along the lower median side of the ovotestis in the groove between the lateral lobes. It passes forward on the inner ventral surface of the anterior complex and widens gradually into the hermaphroditic ampulla, 0.75 mm. in width, total length 29 mm. It continues forward for about half of the length of the anterior complex, then doubles sharply backward to the posterior border, curving outward and forward, thence outward in an irregular course and divides into the oviduct, which at once enters the gland complex and the vas deferens.

The latter, at first 0.225 mm. in diameter, rapidly dilates into a thicker segment, 0.8 mm. to 1.2 mm. in diameter, which is closely looped upon itself and forms the anterior portion of the anterior reproductive complex. The total length of the vas deferens is 20 mm. At its distal end it enters the cylindrical preputium containing within it the glans penis, a short cylindrical organ, 0.5 mm. in diameter, and tapering at the end into a blunt tip, the whole glans measuring 2.6 mm. in length. No sign of an armature can be seen.

The anterior reproductive complex is roughly triangular in outline as seen from above, its base resting against the body wall, and its rounded apex directed obliquely backward and inward. Its dorsal surface is slightly convex, the posterior face directed obliquely inward and backward to a rounded end passing over into the mass. The basal surface is mainly composed of the loops of the vas deferens, its prostatic segment, and the penis, behind which is the vagina, the duct of the spermatheca forming a con-



spicuous loop upon the dorsal surface. Upon the ventral surface is the hermaphroditic ampulla and the proximal end of the vas deferens and the oviduct. The length of the anterior genital complex 5.1 mm., width 6.8 mm., height 4.8 mm.

The *nidamental-albumen gland* complex is relatively small. The mucous gland occupies the anterior inner face of the mass and is obliquely overlaid behind by the anterior part of the large spermatheca. Its duct opens externally by a common opening with the vagina. The small white albumen gland appears on the outer posterior face, resting upon the mucous gland in front under the spermatheca, its inner margin overlapping the latter which lies in a large groove formed by the mucous and albumen glands externally and the loops of the hermaphroditic ampulla ventrally.

The *spermatheca* is a relatively large sac about 3 mm. wide by 7 mm. long, with a duct 10 mm. in length, 1 mm. in diameter.

The *spermatocyst* is an irregular saccular structure packed full of sperm. Its duct arises from the outer anterior part, passes inward, and loops back outward to open with the gland duct close behind the preputium. Length of duct 10.4 mm., sac 5 mm. by 6.4 mm.

The *vaginal duct* lies transversely across the dorsal surface just behind the penis. Its distal vagina tapers from 1.0 mm. diameter just beneath the integument to 0.6 mm. at a distance of 3.2 mm., thence continuing to the inner margin of the complex, looping backward and returning to pass beneath the vagina. This loop is embedded in a groove on the surface of the gland.

*Systematic relationships.* Cooper's original description, 1862, reads as follows:

*"Pleurophyllidia Californica* n. sp.

"Sp. Ch.—Form ovate, obtusely rounded in front, subacute posteriorly, back nearly smooth, gray, with about fifteen slightly elevated white stripes arising alternately from either end, and interlocking regularly together at various distances, each terminating in a sharp, bluish point. Broad expanded veil black, with a white margin. Lower tentacles very small. (eyes none ?) upper tentacles on vertex. Foot narrower than mantle, ovate, sharp behind, laterally expanded into a narrow membrane. Color reddish; branchiae of a darker shade. Length,  $2\frac{1}{2}$  inches, breadth,  $1\frac{1}{4}$  inches.

"This species closely resembles *P. lineata* of southern Europe, with which a comparison will be required in order to point out the essential differences. From the distance of locality there can, however, be no identity of species. Inhabits San Diego Bay, where I found them very numerous in December, crawling and burrowing on the sandy flats. After the floods in January, none were to be found."

More detailed descriptions were given by Bergh (1890, 1894, 1904) based upon material from Panama, Lower California, and Oregon, and its characteristics were clearly established.

In 1876 Bergh published a description of *Pleurophyllidia vancouverensis* based upon a specimen in the British Museum which closely resembles *A. californica* but in which the radula characteristics are possibly sufficiently different to separate them. Ac-

ording to Bergh, the structure of the radula in the various species of this genus (family) are more distinctive than in almost any other nudibranch genus (family). Since Bergh's familiarity with the different species is unquestionably far greater than any other investigator, *Armina vancouverensis* should probably stand until the study of a series of specimens from the Puget Sound region may decide the question.

O'Donoghue (1922, 1924) collected a number of specimens of *Armina californica* (Cooper) from the Vancouver Island region by dredging in from 15 to 35 fathoms, recording this species as widespread but nowhere common in that region. His specimens ranged up to 48 mm. in length, considerably larger than Bergh's. The radula ranges up to 32 (46:1.46) with the teeth substantially as here given. The general ground color of the dorsum is given as varying from a tawny yellow to deep chocolate. The arrangement of the white lines upon the dorsum, however, is quite different.

He stated (1921, p. 179) that the white lines "start at the middle and pass outwards at a small angle," and in 1922 (p. 124) the same statement is repeated. In 1924, page 11, in describing a new species, *Armina columbiana*, he emphasized the point that "no lines start from the middle line as in *A. californica*." No such relation of the dorsal lines to the median one has been seen, and in all cases examined the lines are arranged as indicated in the foregoing description. Only in the case of the innermost secondary and tertiary intercalated lines could they be described as arising from the median one, and the description of O'Donoghue would lead one to conclude that the whole system of some 30 lines bore that relation, which is manifestly incorrect. The statement evidently does not convey what the author intended.

*Armina columbiana* O'Donoghue, dredged in the Vancouver Island region, is a large species measuring 85 mm. and 73 mm. in the two specimens taken by O'Donoghue. The radula formula reaches 58 (91.1.91), being somewhat larger than the maximum 52 (81.1.81) found by me for *A. californica*.

As nearly as can be determined from the description, the form of the teeth is similar, the cusp of the median lacking a basal denticle, and the single needle-like denticle on the outer margin of the laterals is replaced in the outer portion of the rows by smaller denticles up to six in number, and all disappearing in the outermost eight or nine.

## Superfamily DENDRONOTACEA

### Family DUVAUCELIIDAE

#### HISTORY OF THE FAMILY.

The earliest description of a member of this family is given by Dicquemare in 1785 in Rozier's "Observations sur la Physique, sur l'Histoire Naturelle et sur les Arts," volume 27, pages 262-264, and the animal is termed by him "la Palmifere." It forms one of the earliest descriptions of any nudibranch.

Three years later it was followed by Pallas (1788) with his description of *Limax tetraquetra* from the Kurile Islands, now *Duvaucelia tetraquetra* (Pallas), and discussed in the present paper.

In 1798, in his *Tableau Élémentaire de l'Histoire Naturelle des Animaux*, Paris, An. 6, page 378, Cuvier proposed to separate from the genus *Doris* of Linnaeus those forms which have branchiae in the form of plumes, leaves, or branches arranged in two lines along the margins of the back, giving to them the generic name *Tritonia*. In the *Règne Animal*, 1817, it is precisely so recognized on page 391.

Unfortunately he did not designate a type for this new genus which would evidently include several genera as now recognized, and it was not until 1802 that his detailed anatomical study of *Tritonia hombergii* made it clear that this form, though not definitely so designated, was to be taken as the genotype. He indicated also that *Limax tetraquetra* of Pallas (1788) is at least closely related, as probably is also *Amphitrite frondosa* Ascanius, if not identical, though lack of opportunity to consult the original description of Ascanius prevented him from making a decision in this regard.

Lamarck (1801) adopted the generic name *Tritonia* in his *System des Animaux sans Vertèbres*, page 65, indicating *Doris clavigera* O. F. Müller as the type. This species, however, was later shown to be entirely different, and was separated as the type of the genus *Triopa* Johnston, 1838. Finally in 1817, in the first edition of the *Règne Animal*, volume 2, page 391, *Tritonia hombergii* Cuvier is definitely designated by Cuvier as the type of the genus *Tritonia*.

In the meantime, however, the name *Tritonia* was regularly applied to a genus of Diptera by Jean Guillaume Meigen (1800), *Nouvelle Classification des mouches a deux ailles* (Diptera L.) d'après un plan tout nouveau, Paris. An. 8, (1800), page 33, *Tritonia*. This antedates Lamarck's *Tritonia clavigera* (O.F.M.) of 1801 and invalidates the use of *Tritonia* as a generic name for Mollusca by Cuvier and Lamarck.

It is consequently preoccupied and cannot be rightly used for the nudibranchs, despite the common practice in zoological literature even down to the present, but a few zoologists such as Odhner, Iredale and O'Donoghue, and Thiele are endeavoring to correct the error.

Following the argumentation of Pruvot-Fol (1931) and Winckworth (1932), Odhner, in a later paper (1939), suggested reinstatement of the generic name *Tritonia* Cuvier with *T. hombergii* as type; *T. triegi* as a second species, and limit *Duvaucelia* to type *Tr. plebria* Johnston and to similar forms. This could only be done by the use of the plenary powers of the International Commission of Zoological Nomenclature, as Winckworth has shown (1932, *Journ. Conch.*, vol. 19, pp. 211-252) that Cuvier's name was not proposed in a binary manner and hence is unacceptable under the rules.

#### Genus *Duvaucelia* Risso

*Duvaucelia* RISSO, 1826. *Hist. Nat. . . . de l'Europe Meridionale*, vol. 4, p. 38. Genotype, *Duvaucelia gracilis* Risso.

**Duvaucelia tetraquetra** (Pallas)

Plate 30, figures 3-8; plate 39, figures 8-10; plate 43, figures 1-9;  
plate 44, figure 1; plate 45, figures 1-5

*Limax tetraquetra* PALLAS, 1788. Nov. Act. Acad. Sci. Imp. Petrop., vol. 2, pp. 237, 239, pl. 5, fig. 22. Kurile Islands.

*Doris tetraquetra* (Pallas), Gmelin, 1791. Syst. Nat., Ed. 13, vol. 1, pars 6, p. 3106.

*Tritonia tetraquetra* (Pallas), Bergh, 1879. Nudibr. Moll. North Pacific Ocean. Alaska. I, Proc. Acad. Nat. Sci. Philadelphia, vol. 31, pp. 98-105, pl. 3, figs. 13-16; pl. 4, figs. 5-12; pl. 5, figs. 1-2. Unalaska, Aleutian Islands. O'Donoghue, 1922. Notes on Nudibr. Moll. Vancouver Island Region. Trans. Roy. Can. Inst., Toronto, vol. 14, pt. 1, pp. 146-149, pl. 5, figs. 1-5.

*Sphaerostoma gigantea* (Bergh), O'Donoghue, 1926. List Nudibr. Moll. Pacific Coast. Trans. Roy. Can. Inst., Toronto, vol. 15, pt. 2, p. 204.

*Tritoniopsilla tetraquetra* (Pallas), Odhner, 1936. Nudibranchia Dendronotacea. Mém. Musée Royal d'Histoire Naturelle de Belgique, ser. 2, fasc. 3, pp. 1079-1080.

Odhner assigned *Tritonia tetraquetra* (Pallas) (syn. *Tritonia gigantea* Bergh) to the genus *Tritoniopsilla* on the basis of the median tooth only. While the median tooth has but one cusp in "*tetraquetra*" and the first lateral is a simple hook, the remaining laterals are not slender and filiform, the mandibles are quite different, the back has no median ridge, and the rhinophore sheath has no gill-like processes.

Four specimens of this species were available for study.

Number 1. A living specimen taken on August 24, 1898, by a Chinese fisherman in deep water off Monterey Bay, California. (Pl. 30, figs. 5-8.)

Numbers 2 and 3. Two specimens taken by Dr. Frank W. Weymouth off Petersburg, Alaska, from a depth of about 20 fathoms, and preserved in formalin.

Number 4. One specimen dredged on November 19, 1924, by Col. Clyde Dorsey off the Golden Gate entrance to San Francisco Bay, and by him presented to Dr. Walter K. Fisher, director of the Hopkins Marine Station at Pacific Grove, California who kindly turned the specimen over to me.

Numbers 1, 2, and 3 were dissected, and Number 4 has been preserved intact. The following account is based upon all of them, individual differences being noted under the respective serial numbers.

The following general external description was made from the living Monterey specimen Number 1 taken August 24, 1898.

*Body form* stout, subquadrilateral, depressed, narrowing behind to a short, abruptly rounded tail. Highest nearly midway of body, thence sloping rapidly to the tip of the tail, and anteriorly less abruptly to the rhinophores, from thence very abruptly to the velar margin.

The *notum* slopes gently from the median line toward the sides of the body, the lateral margins widely overhanging the sides to at most 5 to 11 mm., forming a deep

groove between the edge of the dorsum and the foot, which is carried around the posterior end above the tip of the tail. (Pl. 39, figs. 8-10. pencil drawings.)

In front, the dorso-lateral margin is continued to the antero-lateral face of the rhinophore sheaths with which it is fused. In front the dorsal surface expands into a broad veil extending laterally in thin, rounded lobes which join the sides of the body below the anterior ends of the dorso-lateral ridges. Its margin is thin and nearly smooth, with a few, eight or nine, low, blunt, tubercle-like papillae near the mid-line. Laterally, a few slightly longer papillae may be made out as flattened projections from the thinner margin. (Pl. 39, fig. 9.)

At the outer angle of the velum, and at a slightly lower level, is a short externally grooved tentacle, scarcely separable from the velar edge and almost obscure. Different degrees of contraction vary the appearance of the margin somewhat. In the preserved specimen (No. 3), the velar margin is nearly smooth. Toward the lateral angles the margin becomes thinner and shows a few flattened lobules, as if formed from broadly flattened short expansions. The anterior tentacles in this specimen are quite obscure. Living specimen (pl. 39, figs. 8, 10).

The *notum* is covered with closely set large and small mammillated tubercles, circular or oblong in outline. The general color of the dorsum in life is a deep rich orange-yellow, each tubercle being tipped with white. In preserved material the orange color is lost and the tubercles may be conspicuous or somewhat obscure. The tuberculate surface continues laterally to the margin of the back and in front to the edge of the veil.

The undulating body margins bear an irregular series of low white plumose bi- and tripinnate branchial appendages, disposed in a single series extending around the whole circumference of the notum above the tip of the foot behind. The undulations of the margin form a close series of smaller and larger curves, alternately up and down; the plumes at the summits of the upward curves are directed upward and outward, those of the downward curves are smaller and directed downward and inward.

In many cases the branchial tufts have been rubbed away and it is understood, easily, that all might be obliterated by such rough handling as they would receive in a dredge filled with hundreds of floundering fishes.

In Number 4 alone (the Dorsey specimen), mainly on the left side, they are exceptionally well preserved, being large with long feathery branches, the largest tufts reaching 10 mm. in height. The curves are not in strict alternation of large upper and small lower ones, but rather one to three of the smaller occur between the larger. (Pl. 30, figs. 3, 4.)

The *rhinophores* are retractile within high sheaths with rather thick walls, the free margins being thinner and nearly smooth. The outer surface of the sheaths is covered with tubercles similar to those of the dorsum, but smaller. The margins are continuous laterally with the margin of the notum, which bears small gill processes close to this union. In front the margins are partially interrupted, the inner one dropping abruptly to a lower level of slightly more than half its previous height, the outer edge is con-



tinued downward and unites with the anterior end of the dorso-lateral marginal ridge. The tapering rhinophore stalks terminate above in a blunt cylindrical tip. Encircling it, below the summit, are borne from six to ten vertical, bi- and tripinnate short plumes, the hindmost one aduate to the shaft, the others free from it, save at their origin below, well within the rhinophore sheath. (From life, pl. 39, figs. 8, 9, 10.)

The *foot* is broad and smooth, nearly as wide as the dorsum, truncately rounded in front, with a bilabiate margin obscurely emarginate in the center, the bilabiate portion extending around laterally well beyond the level of the reproductive opening about 35 mm. The wide pedal margin projects well beyond the sides of the body. The foot is somewhat linear in outline, the posterior end tapering to the short, bluntly rounded tail. Its general color in life is light salmon-pink, its thickened margin edged with a narrow line of white, the groove between the lips of the anterior margin well defined. The upper surface of the foot is sharply set off from the sides of the body. It is of an orange-yellow color slightly lighter than the dorsum, finely papillose or tuberculate, each elevation usually being tipped with a minute white spot. (Living specimen, pl. 39, fig. 9.)

The under surface of the *veil* is slightly roughened and of a somewhat deeper tone of salmon pink than the foot. The mouth region is 13 mm. long by 26 mm. wide, having large fleshy lips rounded into full puffed folds. (Pl. 39, fig. 9.)

The *anus* is situated at the summit of a nearly cylindrical papilla close beneath the dorso-lateral margin, inclined backward and upward, its base 20 mm. behind the reproductive openings. Height of papilla 5.0 mm., diameter 3 mm. at base, 2.2 mm. at summit, aperture round, wide, its edges thin and slightly irregular (denticulate). The much smaller renal opening is directly in front of it at a distance of 8 mm., not below it, as given by Bergh (1879, p. 100; and 1880, pl. 3, fig. 15, p. 126).

The *reproductive openings* are located well forward on the right side midway between the dorsum and the foot about 16 mm. behind the level of the rhinophores, considerably farther forward than is usual in other Duvaceliidae. A short, thick, spirally twisted flap exists between these openings.

*Dimensions.* The length of the living animal was 150 mm., its greatest width 60 mm., the foot was 130 mm. long, its maximum width 54 mm. The veil reached 45 mm. in width, the head immediately at the posterior angle of the veil was 28 mm. wide. For the same specimen, preserved, the length over all is 125 mm., the maximum width 55 mm., maximum height 20.3 mm.; the foot is 110 mm. long and 50 mm. wide. The edge of the dorsum projects beyond the sides of the body to at most 9 to 11 mm.

The two Alaskan specimens were used for comparison. The first measuring 75 mm. in total length, 40 mm. in width, and 21 mm. in maximum height. The second one, somewhat less contracted than the first, measured 65 mm. in length, 27 mm. in width, and 15 mm. in height.

The general body form is the same, the margin of the dorsum projecting widely (7-10 mm.) beyond the sides of the body, the small branchial plumes are present at in-



tervals, are strongly contracted, and easily rubbed off. The dorsum is tuberculate, and under a lens the most of the tubercles show a low central nammilla.

The fourth specimen, taken from San Francisco Bay by Col. Dorsey and preserved in formalin, measures 95 mm. in length, 46 mm. in width, and 26 mm. in maximum height. The notum is nearly smooth, but shows traces of closely set rounded tubercles. The velar margin is entirely smooth, the undulating dorso-lateral margin broadly overlaps the sides and bears a closely set series of low, arborescent, gill plumes arranged in an undulating line. The margin forms a somewhat thickened ridge forming a series of larger and smaller scallops, close underneath the border of each of these is borne a gill plume, the larger situated at the crest of the highest scallop and directed upward, the intervening one to three smaller plumes placed at the tops of the smaller scallops and directed downward.

The dorsal body wall of specimen Number 1 is thin and flexible in the median line, becoming thicker and more resistant laterally. The foot is completely relaxed, soft, and flaccid. The two Alaska specimens are firmer and more leathery, owing to their contracted condition.

*Mandibles.* The pharyngeal bulb is strikingly smaller than usual in the genus, measuring from one-fifth to one-sixth the length of the body as preserved. The ratio existing between the length of a specimen and the dimensions of its pharyngeal bulb is a variable element due to fixation.

The posterior half of the bulb has somewhat the form of a wide, truncated cone, the anterior half more cylindrical. Above and upon the sides a curved band marks the partly exposed, lateral border of the mandibles. They occupy the anterior face and the anterior half of the ventral surface of the bulb. In figures 1 and 2 of plate 43, two views of the united mandibles are shown as freed from the bulb and their musculature from which an idea of their form may be gathered. United at their dorsal hinge region the two mandibles have a somewhat helmet shape. Their anterior ventral surface is convex, strongly so near the median opening and becoming more flattened laterally. The upper hinge region is but slightly concave in front. The inner surface is deeply concave near the median opening and less so laterally and behind. The color of the mandible is a light yellow, deepening to light brown toward the anterior margin. The two mandibles are united at the hinge by a strong transverse ligament, visible from above and behind.

In front of this ligament the thinned and beveled margin of the right mandible overlaps that of the left for about 4 mm., rather than presenting a flattened, articular surface parallel with that of the left one. That this overlapping is not accidental is shown by its presence when the lower masticatory margins are in opposition and by the beveled surfaces of contact, the right upon the left. The same condition is shown in all three specimens, and is clearly visible in Bergh's figure (1879, pl. 4, fig. 7), though he makes no mention of it in the text. In his description of *Tr. gigantea*, which is very probably identical with *Tr. tetraquetra* (Pallas), Bergh (1904) states that "die innere Randparthie der rechten deckte breit die der linken" but gives no figure. He evidently saw the same condition as here described. O'Donoghue's outline figure (1922, pl. 5, fig. 1) gives no

detail in this region, the two mandibles being represented as completely united, which may be questioned.

Below the hinge region the mandible margins are separated by an elongate oval space, widest above and narrowing below to a linear shape, the biting edges coming in contact in the last third of the margin. This space is due to wearing away of the masticatory margin through use. Only the lowermost portion and the free process show no wear. The latter is short, and is connected laterally with the body of the mandible by a thin, web-like expansion of much lighter color.

The cutting edge is smooth, and limits a narrow border of about 0.1 mm. in width, beyond which the surface presents a quite uniformly tessellated appearance in a zone of approximately 0.9 mm. in width. These areas are quite small, irregular polygons, ranging from 0.006 to 0.012 mm. in diameter, arranged in irregular rows, becoming fainter and dying away toward the outer portion of the zone. Eighty to 100 or more of these rows may be made out. Each such polygon represents the end of a short prism of chitinous material; each is slightly convex and minutely roughened on its free surface. No indication of a projecting cusp, such as is found in *D. festiva* and *D. exsulans* (pl. 43, figs. 3, 4), can be made out.

Bergh (1879, pl. 3, fig. 16) figured a somewhat similar structure, but his statement that these "irregular prismatic bodies are about 0.02 mm. high" is obscure. If he means that they project that much above the level of the process, it is clearly different from what is here found.

*Radula.* The pale yellow radula of Number 1 is quadrangular in form, 11 mm. long by 14.4 mm. wide when flattened out. The teeth are arranged in 81 transverse rows. The first of these are incomplete and worn, the median tooth and a few laterals adjacent to it being alone represented in about 14 rows. The rows appear to be complete from about the 20th on. From the 37th on they are inclosed in the radula sheath. In the 28th row, there are 266 laterals on each side of the median tooth, in the 74th row they reach 312 in number, which appears to be close to the maximum. The single, median tooth (pl. 43, fig. 5) is long and laterally compressed, being much narrower than that found in most other Duvaceliidae. The base is rather thick, sloping downward behind to a blunt point and deeply notched in front, the groove being continued upward on the median line of the stout, low, compressed hook. This notch receives the point of the cusp of the preceding tooth. No indication of minor cusps, lateral to the single median one, is to be found. The length of the base is 0.150 mm. in the 30th row, 0.165 mm. in the 46th, and 0.168 mm. in the 78th, with the same width of 0.060 mm. in each. The height of the point of the hook above the base line ranges from 0.055 mm. to 0.084 mm.

The first lateral (pl. 43, fig. 6) is very much compressed, and in its general form resembles the other laterals much more than is usual in other species of the genus. The base is usually slender, slightly broader behind than in front. Its length is 0.135 mm., its width 0.030 mm. in the 30th row, increasing but slightly toward the younger rows of the radula, and remaining shorter in length than the median. The hook is compressed

and nearly erect, the height of the tip above the base line reaching 0.084 mm. The remaining laterals (pl. 43, fig. 7) are strongly compressed, their bases narrowed, and slightly curved, and bear above a strong, moderately curved hook. The anterior margin of the hook is a simple, smooth curve save for a small, triangular denticle (pl. 43, fig. 8) situated at somewhat less than half way up its length and slightly to the inner side rather than on the exact edge. This position frequently obscures its presence. The height increases rapidly in the innermost three or four to from .225 mm. to .300 mm., and then continues fairly uniform to the outermost five to seven which decrease very rapidly in size to a mere rudiment in the outermost lateral. (Pl. 43, fig. 9.)

The hooked form of the teeth is preserved throughout the rows and nowhere is there an indication of a filiform or excessively slender shape, such as is given as characteristic for the genus *Tritoniopsis* Eliot, 1905 (= *Tritoniopsilla* Pruvot-Fol, 1933), to which *D. tetraquetra* (Pallas) has been assigned by Odhner (1926).

Eliot (1901) gives but scanty details of the radula of his *Tritonia* species, but so far as indicated they show practical identity with *D. tetraquetra*.

The radulae of specimens Numbers 2 and 3 are in substantial agreement with that here described for Number 1.

Specimen	Body Length	Formula	Location
<i>D. tetraquetra</i> No. 1	150 mm. (living)	81 (312 · 1 · 312)	Monterey Bay
<i>D. tetraquetra</i> No. 2	75 mm.	70 (224 · 1 · 224)	Petersburg, Alaska
<i>D. tetraquetra</i> No. 3	65 mm.		
Bergh (1879)	75 mm.	50 (225 · 1 · 225)	Unalaska
Bergh (1904) "T. gigantea"	140 mm.	94 (250 · 1 · 250)	Unalaska
O'Donoghue (1922)	200 mm.	57 (233 · 1 · 233)	Puget Sound

From these measurements it would appear that the formula 50-94 (225-312 · 1 · 225-312) represents fairly well the dentition recorded.

*Salivary glands.* Two pairs of salivary glands are present. The anterior pair (pl. 45, fig. 5) corresponding to the "ptyaline glands" of Bergh, lies in contact with the posterior, lower face of the pharyngeal bulb, on either side of the radula sac elevation. They are thick, lobulate glands of a whitish color, pressed closely between the posterior end of the bulb in front, the oesophagus above and behind, and the inner surface of the foot and the body walls laterally.

The gland is made up of densely packed finely granular cells. The duct ramifies into many subdivisions which at once divide into the closely packed lobules and terminate in short tubular ramifications, the whole gland being thus of the compound tubular type. The secreting cells are small, cuboidal, and packed with fine acidophile secretion granules in the specimen sectioned. The anterior salivary glands are entirely independent of the posterior pair. The left gland is 7.6 mm. in transverse diameter and 4.0 mm. in greatest antero-posterior length. The right gland is 7.3 mm. wide and 5 mm.

long. In the Alaska specimen they scarcely meet each other in the median line; in the Monterey Bay one they were more extensive, meeting in the median line, and extending laterally up around the stomach.

From each gland a clearly defined, slender duct arises from its middle, inner face, and extends forward in contact with the lower surface of the bulb, the two converging toward the median line of the mouth tube. Here they pass through its thick, reflected wall, diverge slightly, and open ventrally into the mouth tube in front of its inner aperture. The duct is lined by ciliated cuboidal epithelium resting upon a strong connective tissue wall.

No similar gland seems to have been found previously in any of the Duvaulciidae. It is not mentioned by Bergh in any of his studies, especially in his description of the anatomy of *D. tetraquetra* (Pallas). It is difficult to understand how he could have overlooked it for they are unmistakable. O'Donoghue says nothing of it in his fragmentary account of the same species.

The *posterior salivary* glands, the pharyngeal glands, are diffusely ramified structures of a pale orange color, located laterally to the oesophagus just behind the pharyngeal bulb. Their flattened branches are closely bound down to the oesophagus, extending ventrally around beneath it and meeting there. Posteriorly they extend along the oesophagus for about equal distances, some 5 mm. In the Alaska specimens, Numbers 2 and 3, the anterior and posterior salivary glands are sharply distinct in size, color, and texture, the anterior pair being large, white, thick, and compact, the posterior pair smaller, pale orange, flattened, and diffusely ramified. In the larger specimen from Monterey Bay, Number 1, the two pair show more similarity, the posterior tending to the same thick compact form. The color is distinct, however. The ducts of the posterior pair extend forward from their anterior ends along the oesophagus through the nerve ring, and open through the roof of the bulb into its cavity above the radula.

*Oesophagus.* The short and wide oesophagus dilates into the capacious, thin-walled stomach lying in a broad groove in the ventro-anterior surface of the liver. It curves to the right and passes upward through a deep sulcus, and appears on the dorsal surface immediately below the heart, thence passing to the left into the intestine, which makes a right-angled turn, passes forward in a deep groove, and describes a loop around the anterior end of the liver to the right side, and thence with a second right-angled turn passing backward and upward to the anal opening.

*Stomach.* From the notes made during the dissection of specimen Number 1 from Monterey Bay, the following description of the external appearance of the gastric girdle was made: on the dorsal surface of the stomach appears a strong band encircling it. This is white and glistening, showing the circular muscular fibers of its wall and more strongly the longitudinal ridges of its surface corresponding to the internal ridges of its wall. This pyloric girdle is a very conspicuous feature on the surface of the stomach of all the specimens dissected, and it is difficult to understand how Bergh, and later O'Donoghue, failed to see it. Bergh (1879, p. 103) speaks of "a rather narrow pylorus with very strong folds" as he describes the stomach.

The lining of the stomach is smooth, showing no distinct folds in the anterior part. Into its pyloric portion open three wide ducts leading into the liver, one anterior to the right anterior lobe of the liver, one on the left side, and one posterior. The openings of the first two ducts are close together, and in a distended stomach may have a common general opening into that organ.

At the point of emergence of the stomach from the liver groove on the right side, its wall becomes much thickened by the development of a strong muscular girdle immediately in front of the origin of the intestine. The width of this pyloric girdle is 10.5 mm., the diameter of its opening is 6.0 mm., and its lining presents some 12 to 15 low, longitudinal folds, some running the full width of the band, other, lower ones, more incomplete, alternating with or joining the larger ones after a longer or shorter course. In front of the girdle a number of low folds in the gastric wall converge toward the circle, two higher ones alone continuing through it. Their anterior ends extend beyond the anterior margin along the floor of the stomach and die away close to the opening of the biliary passage from the liver. (Pl. 45, fig. 3.)

Posteriorly, beyond the girdle, the more prominent of these ridges is continuous with a thick, fleshy, typhlosole-like fold of the intestinal wall, some 2 mm. in height, which occupies the ventral surface of the intestine, continues around its anterior loop, terminating in a free, lobe-like process 8.0 mm. long. A few lower folds of the intestinal lining parallel to the main one extend along the lesser curvature of the intestinal loop and die away within it.

A typhlosole of a similar nature is described by Vayssière for *Marionia*, and, contrary to the opinion there expressed, is found in many other genera of Opisthobranchs.

The columnar epithelium of the gastric girdle bears a thick light-brown cuticle which is readily detached as a whole with more or less of the epithelium adherent in the preserved specimen. It repeats the ridges and grooves of the surface, is thickened at the crests of the ridges, and is continuous in the sulci between them. In the sulcus between the two higher ventral ridges, the cuticle is completely interrupted. Sections show that this particular groove is lined by columnar ciliated cells forming a duct-like furrow for the passage of the liver secretion directly back into the intestine.

*Measurements* from sections. The thickness of the gastric girdle at the bottom of the ridges is approximately 0.33 mm.; height of the gastric ridges 0.60 mm.; muscle layer thickness 0.15 mm.; cuticle at the top of the ridge 0.072 mm.; cuticle in groove 0.036 mm. The epithelial cells average 0.024 mm. in height and are borne on a compact layer of fibrous connective tissue. The innermost zone of cuticle is lighter in color, and less dense than the outer portion. (Pl. 45, fig. 2.)

The *epithelium* bearing the cuticular thickening forms an efficient triturating apparatus which reaches its higher development in the genus *Marionia* in which, judging by accounts of Vayssière and Bergh, the cuticle covering the ridges forms a series of separate, parallel, blade-like teeth, which may be readily detached from the folds upon which they rest. (Pl. 45, fig. 4.)



Unfortunately no one seems to have examined such species as *T. hombergii* in this regard; at least, no account has been found in the literature of the existence of any such epithelial modification in that species comparable in any way to the gastric teeth of *Marionia*.

In a personal communication, Dr. N. Hj. Odhner informs me that the stomach wall of *Tritonia hombergii* is smooth back to the openings of the liver ducts. Beyond this point the pylorus develops a ring of some six to eight smooth and soft folds, not cuticularized.

As Odhner has pointed out, the fundamental morphological characteristic of *Marionia* is the presence of a separate right anterior lobe of the liver, with its independent duct.

The liver is a soft, finely lobulate mass, light brown in color, tapering behind to a bluntly rounded extremity conforming to the shape of the body space. The anterior end presents a ventral excavation for the stomach, extending dorsally as a deep notch or sulcus, and prolonged obliquely forward and to the left as a deep groove for the reception of the first portion of the intestine.

In this loop, a large lobe forming the right anterior end of the liver is circumscribed by the alimentary canal, remaining, however, in connection with the posterior portion of the liver in the left anterior portion and is drained by a large separate bile duct opening in front of the gastric girdle.

In the dissecting notes is the following: An anterior right lobe of the liver lies above the right posterior end of the stomach. The posterior dilated end of the stomach passes upward as a roomy pyloric portion. Into this opens a duct from the anterior lobe on its anterior upper wall, and a posterior duct from behind and above. At the right between the two is a rounded crescentic opening with a muscular sphincter surrounding it.

The stomach and intestine were distended with ingested food material consisting largely of coral-pink fragments of irregular sizes, some of them reaching 7.8 mm. in length by 3.5 mm. in width. In the intestine these fragments become smaller and smaller until in the rectum the contents are a reddish, soft, semifluid mass, the color due to separate spicules of an Alcyonarian, probably *Euplexaura marki*. In the process of digestion, the large skeleton fragments are resolved into their constituent spicules by the dissolution of the tissue of the colony, the main break up taking place in the intestine. The color does not seem to be affected by the digestive processes or by the after preservation in alcohol.

*Reproductive system.* The anterior genital complex of Number 1 (pl. 44, fig. 1) is surprisingly small for so large a specimen. The accessory glands are united in a compact, elongated, prismatic mass closely enmeshed in loose connective tissue. Its outer face is flattened against the body wall; its ventral face is likewise flattened, its dorsal face is convex, its inner face bears a deep, longitudinal groove containing the elongated, thick-walled spermatheca and its duct leading forward to the vagina. The posterior



end of the complex is covered by the close loops of the hermaphroditic ampulla, and in part by the deflected proximal end of the spermatheca. The ampulla is some 24 mm. long with a diameter of about 0.8 mm.

The exposed surfaces of the gland complex show the irregular windings of the mucous gland, especially striking on the postero-dorsal surface, where they form a series of narrow, approximately parallel, undulating white folds alternating with narrow, translucent stripes. The remaining surfaces show broader and more irregular convolutions, except on the outer anterior border where a small ovoid area of close narrow gyri gives the general appearance and consistency of an albumen gland.

The hermaphroditic duct, from the thin layer of the ovotestis covering the liver, joins the proximal end of the hermaphroditic ampulla at the posterior end of the gland complex. The distal end of the hermaphroditic duct is deeply buried between lobules of the albumen gland and is quite difficult to follow. It narrows abruptly and divides into the oviduct and the vas deferens, the forking being concealed below the surface. The former passes directly into the gland lumen; the latter passes forward and outward along the anterior surface of the mucous gland in the groove between it and the overlying spermatheca. Making a sharp turn upon itself, it passes inward and forward to the proximal end of the preputium, dilating in its course from a diameter of 0.5 mm. to 1.8 mm. as it enters the latter. This portion is thick-walled and may possibly be regarded as representing a prostatic segment. The length of the free portion of the vas deferens, from its point of separation from the gland complex to the base of the preputium, is 7.0 mm.

The preputium is an elongated, conical, muscular sac lying transversely in front of the gland complex, opening externally as the most anterior of the three closely associated, reproductive openings at the anterior end of a crescentic depression uniting them. Proximally it dilates somewhat into a blind end from which the retractor muscles pass inward. Within, the preputium is nearly filled by the large, slightly curved, conical glans, the basal diameter of which is 2.5 mm. and its length 7.0 mm. The tip is slightly blunted and is entirely unarmed.

The *vagina*, a stout, cylindrical tube slightly dilated at its distal end, lies close behind the preputium and parallel to it, and opens close behind the penis aperture. Its proximal portion passes gradually into an elongate, sac-like dilation, which lies in a groove upon the dorsal face of the gland mass. This blind sac is interpreted as the spermatheca. The thick muscular tube of the vagina narrows gradually as it passes inward for a distance of 5.5 mm. and then dilates as the spermatheca to a maximum (while contracted) of 3.0 mm. with a length of 9.0 mm. The exact boundary of vagina and spermatheca is not sharply defined in the specimens at hand. The lining of the distal portion bears numerous fine lengthwise folds, the proximal, dilated portion is more irregularly convoluted.

*Nervous system.* The author made a permanent mount of the central nervous system from which a camera-lucida drawing was made, as given on plate 45, figure 1.

[However, he has not completed the manuscript describing this figure. A brief explanation of the figure is given with the plate. O. H. MacF.]

*Systematic relationships.* We agree with Odlner (1936) that this species could be referred to the genus *Tritoniopsis* Pruvot-Fol, 1933, on account of the primitive character of the radula (unicuspitate median, and uniformly shaped lateral teeth) but in other respects it departs widely from the genotype *T. brucei* Eliot, 1905.

The presence of the anterior salivary glands, as described here, is a significant feature, not recorded for any other member of the Duvauceliidae. The presence of a pyloric gastric girdle, lined with folds bearing a thick continuous cuticle, represents an early step in what culminates in the genus *Marionia* as separate, blade-like, or ridge-like teeth, constituting an interesting primitive character, probably to be found in all other Duvauceliidae in a greater or less stage of development.

In the four species of North Pacific Duvauceliidae reported upon in this paper, there exists a muscular gastric girdle with prominent lining folds bearing thickened cuticle upon the summits of the ridges, but thinner, though present in the grooves between them. This is evidently a condition which in the genera *Marionia* and *Marionopsis* culminates in the development of large, blade-like teeth upon the ridges, their basal union being either obscure in contrast, or entirely obliterated.

### *Duvaucelia festiva* (Stearns)

Plate 39, figures 1-6; plate 43, figures 10-19; plate 44, figure 2; plate 45, figures 7, 8

*Lateribranchiaca festiva* STEARNS, 1873. Proc. Calif. Acad. Sci., vol. 5, pp. 77-78, text fig. 1. Point Pinos, Monterey Bay, California.

*Tritonia reticulata* BERGH, 1881. Beiträge zur Kenntnis der Japanischen Nudibranchien 11. Verh. k. k. Zool. - Bot. Gesellsch. Wien, pp. 239-250, pl. 8, figs. 7-20; pl. 9, figs. 1-12; pl. 10, figs. 1-10.

*Sphaerostoma undulata* O'DONOGHUE, 1924. Trans. Roy. Can. Inst., Toronto, vol. 15, pt. 1, pp. 3-6, pl. 1, figs. 1-4. Gabriola Pass, Vancouver Island Region, 10-18 fathoms; Parlier Pass, 8-15 fathoms.

*Tritonia festiva* (Stearns), JOHNSON and SNOOK, 1927. Seashore Animals of the Pacific Coast, p. 491, pl. 7, fig. 5 (colored).

Stearns described this species very briefly and illustrated it by one figure. For it he made the new genus *Lateribranchiaca*. The specimen was found by him at Point Pinos, Monterey Bay, California, near the lighthouse on the under side of granite boulders at extreme low tide. His genus diagnosis reads:

"Animal like *Triopa*, with a single series of gills on each side, central or sub-central and opposite." Standing alone this description is vague and inadequate according to present standards, but taken with the species description and the figure it becomes much clearer. "Body slug-shaped, about one inch long; of a *translucent* cream white color, on back ornamented with looped linear markings on each side of an opaque *chalky white*, and three irregular, ring-shaped markings of the same color, nearly equi-

distant and along a central line on the back, also marked with a few inconspicuous, irregularly placed orange spots; cephalic tentacles short, clavate, stumpy, fringed at base, branchial orifices on each side, sub-central, with short, arborescent plumes."

A great number of collecting trips in the area indicated by Stearns, which is one of the richest near the Hopkins Marine Station, has convinced me that the animal described by Stearns is undoubtedly the one here described in detail. The original diagnosis is here modified to more clearly define the genus, which, however, is antedated by *Duvaucelia* Risso, 1826.

*Body* (pl. 39, figs. 1-6) limaciform, nearly rectangular in cross section, the back slightly convex, the margins of the foot extending beyond the sides of the body in life, but usually contracted in preserved material.

*Dorsum* smooth or very slightly roughened, highest in heart region about midway of body length, thence sloping very gradually to region of rhinophores, from there rapidly to margin of veil, behind the heart sloping more rapidly to tip of tail.

*Frontal veil* moderate, slightly bilobed by a shallow median emargination. The margin bears 8 to 12 long, slender, tapering, simple processes, the outermost ones the longest, the central ones the shortest, the outer margin of the veil is fused with the dorsal surface of the anterior tentacle, which resembles the processes as seen from above, but is slightly more blunt, deeply grooved on its ventral surface throughout its whole length, and is below the level of the marginal processes. The velum and its processes are directed forward and downward and the latter keep up a constant finger-like tactile movement as the whole veil is alternately lowered and raised. In preserved material the processes may be variably contracted, and the anterior tentacles may become shortened into more or less auriform lobes. Frequently the veil shows mutilation with varying degrees of regeneration.

*Foot* rounded in front, slightly bilabiate, tapering behind to a blunt tip with thin margins. The anterior end is thickly set with mucous glands which extend as a marginal zone back to the tip of the tail, the central area having relatively few.

The *dorso-lateral margin* is thickened into a ridge throughout its entire length. It bears a series of 11 to 15 gill plumes on either side, alternately smaller and larger in an undulating line or series of loops, the larger plumes at the highest points of the loops, the smaller ones on the lower portion of the curve. Posteriorly the smaller ones disappear first, then the larger ones become rudimentary and cease. Each larger plume consists of a low, rather strong, slightly tapering, erect trunk, breaking up into three to four spreading, nearly horizontal, bipinnate branches. (Pl. 39, figs. 5, 6.) The alternation in size, large and small, is not exact, varying in different specimens, but the form of the smaller ones duplicates that of the larger.

*Cardiac elevation* inconspicuous, between the fourth and sixth pairs of branchiae.

*Rhinophores* placed at anterior end of dorso-lateral margins, stout, retractile into well developed flaring sheaths with sinuous undulating margins, the clavus obliquely truncate, tapering to a blunt, posterior tip. Surrounding it is a circle of small, slender, pinnate or bipinnate plumes, closely clustered, erect, and arising from a common level as ridges on the clavus, becoming free above as branching filaments, save the hindermost, which is adnate to the stalk throughout its full extent. (Pl. 39, fig. 4.)

*Mouth* beneath the frontal veil, an oval longitudinal opening surrounded by slightly prominent lips. (Pl. 39, fig. 3.)

*Anal opening* about midway of the right side between gills five or six close below the dorsal margin, at the summit of a low papilla, the minute renal pore close in front and above it.

*Reproductive openings* on right side below gill five, midway of the side, at about juncture of anterior and middle thirds of body length. A slight oval elevation bounded by a faint ridge bears three openings, each at the center of a circular area. The lowest slightly crescentic, the upper two on the same horizontal plane. One opening is that of the penis, the other two of the vagina and oviduct.

General *ground color* a delicate cream through cadmium yellow to burnt sienna. Very fine reticulate lines are on the sides and dorsum, occasionally pronounced, giving the specimen a darker appearance. One specimen recorded had fine brown venations within the oval areas on the dorsum. A varying depth of color is found in the gill and rhinophore plumes. The foot is quite transparent, thin, all being very delicate.

*Body* ornamented with a striking system of narrow lines or bands of opaque white as follows: the foot is edged with a narrow line of opaque white throughout its extent. Margin of the frontal veil and its processes opaque white extending laterally from the dorsal surface of the anterior tentacle to the front margin of the rhinophore sheath. From the hinder margin of the rhinophore sheath a similar opaque white line passes along the margin of the back, undulating in loops, each loop terminating at the base of a gill plume which it encircles, posterior of these continuing to the tip of the tail. A narrow transverse line of opaque white extends across the head connecting the rhinophores and (often) extending up along the inner faces of the stalk to the margin of the sheath. Within the marginal line of white a similar line starting at the rhinophore passes backward, uniting the gill plumes of each side by graceful loops directed toward the middle of the dorsum, becoming indistinct posteriorly.

Mesially from within this series of loops, connecting successive plumes, is another more median one also beginning at the rhinophore and joining the base of every other plume, the large ones by a white line, behind merging with the marginal line of the dorsum. (Pl. 39, fig. 1.) A median dorsal series of larger or smaller, circular or elliptical figures narrowly outlined in white, usually three or more in number. Rhinophore sheaths edged with opaque white, the clavus tipped with white, the encircling filaments light or dark (cadmium) yellow, the gill plumes of similar color. The above white lines may be

continuous and strong throughout, or in part faint or broken. A bright carmine-red spot shows through the integument in the region of the mandibles. On the left side the liver shows indistinctly as a dark mass, yellowish in front, and overlain by an irregularly lobulated whitish layer, the ovotestis.

*Mandibles.* (Pl. 43, figs. 10, 11.) The body wall is very thick and firm, made up of a feltwork of muscle fibers and connective tissue imbedded in a clear homogeneous matrix covered externally by a simple columnar epithelium. A heavy layer of circular muscles surrounds and covers the mandibles in front.

Specimen used, 17.3 mm. long. Pharyngeal bulb 8.5 mm. long, one-half the body length; 6.5 mm. widest point; 5.7 mm. maximum height. The mandibles (pl. 43, figs. 10, 11) form a shield-like covering over the anterior and ventral faces of the bulb, leaving the other surfaces uncovered and formed of strong musculature. They are very pale yellow, nearly colorless, deepening to dark yellow in the younger portion; relatively large and strong, a single mandible about three times as long as wide, 9 mm. by 3 mm.

The mandible margin is made up of a smooth narrow edge which is very resistant to abrasion. Within this are three to five oblique rows of pointed denticles. The pointed tips of each denticle are directed forward and downward. There are nine to eleven teeth in the row passing from the inside to the outside, 0.12 mm. The inner of each row is prolonged as a series of flattened plates becoming shorter and flatter, dying away on the smooth inner surface of the mandible.

Each denticle (pl. 43, fig. 12) arises as a pointed prolongation from the anterior angle of a plate, each plate representing in end view a prismatic rodlet component of the mandible margin.

In the matrix sheath near the end of the process, each one of these cusps is seen to fit down over the end of a rodlet much as the enamel over the dentine in a mammalian incisor tooth. In sections of the tip this layer fits down over the summit of a large formative cell. In the transparent preparation a round outline resembling a nucleus may be made out.

The *radula* (pl. 43, figs. 12-18) is wide, of a slightly square shape, 5 mm. long by 4 mm. wide; there are up to 57 rows of teeth with a maximum of 50 in each half row, 57 (49.1.49).

Median tooth (pl. 43, figs. 13, 14) wide, its base rectangular with rounded angles, its anterior border with a wide shallow median notch, the posterior border slightly concave; above a strong, broadly triangular, bluntly pointed tip, on either side a smaller, more obtuse cusp of similar shape to the median one.

Median tooth in tenth row is 0.174 mm. wide; mid-length, a line tangent to the anterior face, .105 mm.

The ventral view of the median tooth presents a quadrangular base, posterior margin formed by two very shallow curves uniting in a median line below the middle of the median cusp, laterally terminating in acute angles; sides curved, anterior margin rounded laterally, concave in the mid-line.



First lateral (pl. 43, figs. 13, 14) stout, its base somewhat elongate, rectangular or roughly triangular, the surface lowest in front sloping backward and outward to a strong L-shaped ridge with rounded angle, the shorter arm of which is transverse and terminates as a blunt or slightly acuminate projection above the outer hinder corner of the median tooth. Upon its upper thickened margin may be borne a row of minor and major denticles. The major point is .006 mm. high, with .012 mm. the basal width in the 21st tooth. The longitudinal arm is thickened and forms the outer border of the tooth. Extreme length 0.126 mm.

The remaining laterals are compressed hooks of uniform size, save toward the inner and outer ends of each row where they decrease progressively inward and outward. (Pl. 43, figs. 16-18.) The inner posterior angle of these laterals is elevated into a short hook-like prominence. Extending from the anterior margin of this is a thin veil-like extension of the dorsal surface of the tooth around the edges of the base (pl. 43, fig. 17) which is thick and strong.

*Alimentary canal.* The oesophagus emerges from the upper median anterior face of the pharyngeal bulb, widens rapidly as it passes backward and to the left. It is accompanied on either side by the elongate, ramified posterior salivary glands, the ducts of which accompany the oesophagus through the nerve collar and diverge laterally to pierce the wall of the pharyngeal bulb into which they open in front of the anterior border of the radula. No anterior *salivary glands* were found in this species.

*Heart* midway of body length. The auricle is a transverse tube opening medially into the ventricle. Its upper wall shows a transverse series of squarish whitish elevations in a single row, the central four higher and more sharply defined than the lateral ones which gradually become indistinguishable from the surface bearing them. Upon the anterior right wall of the auricle a low bluntly conical eminence projects forward. This may be the pericardial gland described by Pelseneer.

The dilated *oesophagus* passes into the anterior part of the stomach without any line of demarcation, curving downward and to the right ventrally, thence upward to reappear on the dorsal surface, narrowing and describing a loop forward and to the right in the groove of the liver, thence passing obliquely outward to the anal opening on the right side.

In this course it lies in a groove between the posterior and left portions of the liver and an incompletely separated right anterior lobe. On the upper right the anterior lobe sends a duct piercing the anterior wall of the stomach, and from the larger posterior left liver mass a similar but larger duct enters the opposite wall of the stomach. Close behind the openings of these two liver ducts the stomach narrows and its wall develops a prominent but narrow girdle of circular muscle fibers. The epithelium lining of this girdle develops a series of close, low, parallel, longitudinal folds, some 18-26 in number, 0.1 mm. high and 0.4 mm. long, in length corresponding to the width of the muscular girdle. The columnar epithelium bears a strong cuticular layer upon the surface, thickest (0.36 mm.) at the crests of the folds where it often forms a relatively sharp



edge (pl. 45, fig. 8) and thinning away in the intervals between the folds but still recognizable (.002 mm.). In some poorly preserved material, the cuticle tends to become detached in its entirety as a more or less continuous sheet.

As shown in plate 45, figure 12, which represents a cross section of the pyloric stomach in *Duvaucelia exsulans*, these gastric folds do not extend around the full circumference of the girdle, though the outer muscular tunic does so. About one-third of the lining surface is free from the folds and presents an undulating surface, the epithelium of which shows a thin cuticle. At one side of this area, on the ventral wall of the intestine, a broad fold projects into the lumen, bearing a definite cuticle save in the groove between it and the smooth area of the lining. Here it presents one or two minor folds and its cuticular epithelium is replaced by a higher ciliated columnar form. In front of the girdle this high fold continues to the biliary openings; posteriorly it becomes the typhlosole of the intestine and the groove beside it forms a ciliated channel for the hepatic secretion past the plates of the girdle and into the intestine where the main digestive processes evidently take place.

The typhlosole fold continues along the intestine for about one-half of its length and then terminates. Numerous smaller folds of the intestinal lining (pl. 45, fig. 7) extend from beyond the pylorus nearly throughout its whole extent, disappearing toward the anus.

In *Duvaucelia festiva* this triturating apparatus is evidently at a low stage of development, becoming more advanced in other species such as *D. tetraquetra*, *D. exsulans*, and *D. gilberti* as described herein. In the genus *Marionia* Vayssière, the cuticle is thickened to form blade-like teeth which apparently become readily detached from each other and from the gastric wall as independent teeth. Their presence was originally held to be the fundamental generic characteristic of *Marionia*, but Odhner (1934, p. 286) has convincingly shown that the existence of a separate right lobe of the liver is far more primitive and important. No one seems to have examined the histological structure of this gastric girdle in any other of the Duvauceliidae, the descriptions here given being the first recorded. Similar studies of other species are greatly to be desired.

*Central nervous system.* Cerebral ganglia and pleural ganglia intimately fused, the anterior cerebral moiety widened, united behind with the somewhat elongated pleural portion. Cerebral commissure very short and wide. Sub-cerebral commissure delicate, closely united with the sub-oesophageal commissures. Pedal ganglia large, flattened spheroidal in form, united with the cerebral and pleural ganglia by short but distinct cerebro-pedal and cerebro-pleural connectives. Buccal ganglia ovoid, large, the cerebro-buccal connectives long, slender, a small gastro-oesophageal ganglion united with each buccal ganglion by a short connective, and sending numerous delicate nerves to the oesophagus and the stomach. Eyes deeply imbedded in the integument close below the rhinophores. At the base of each rhinophore there is a relatively large ganglion. Statocysts small, close behind the pleuro-pedal connectives united by a delicate nerve to the cerebral ganglia, seen best in serial sections.

*Reproductive system.* (Pl. 44, fig. 2.) The yellowish white ovotestis covers the general surface of the liver more or less completely, depending upon the maturity of the specimen. From it the hermaphroditic duct passes forward to the anterior genital complex and dilates into the relatively long hermaphroditic ampulla (*h. a.*) closely looped upon the inner surface. From its anterior narrowed end it gives off the vas deferens (*v. d.*) and passes as the oviduct (*ov.*) into the lumen of the accessory glands.

The *vas deferens* is rather short and thick and is lined with high columnar cells with finely granular contents and basally located, deeply staining nuclei. Between these gland cells are interspersed slender cells bearing cilia at their distal ends, appearing as slender tufts between the gland cells. This segment of the vas deferens is probably prostatic in function. Its proximal end narrows and the granular gland cells are replaced by clearer columnar ones, which, in turn, pass over into the lower ciliated cells of the hermaphroditic ampulla. The distal end of the vas deferens enters the dilated base of the penis, consisting of a cylindrical muscular sac the preputium (*pr.*) inclosing within it the terminal glans penis (*g. p.*). The *glans*, when retracted, is a cylindrical or somewhat urn-shaped structure arising from a broad muscular base at the proximal end of the preputium. The wall of the preputium is thick and muscular, the centrally placed vas deferens is surrounded by loose connective tissue inclosing roomy vascular channels or sinuses. The length and breadth of the glans are nearly equal; its distal truncate end is slightly concave and is bounded by a thin, slightly flaring margin which bears a row of minute papillae.

In the center of this disk is a short conical papilla, at the tip of which the vas deferens terminates. This tip is eversible to a small extent and is more in the form of a thick flap with a curved tapering outline and lying parallel with the surface of the glans. (Pl. 44, fig. 2.)

Height of cylindrical portion 1.0 mm.; major diameter of cylindrical portion 0.7 mm.; major diameter of top disk 1.7 mm.; minor diameter 1.2 mm.

Immediately behind the external opening of the male channel is that of the *vagina*, entirely separate from it. It consists of an expanded roomy tube leading by a slender duct at its inner end into the receptaculum seminis or spermatheca (*spc.*), an elongate ellipsoidal blind sac. Close behind, and slightly below the opening of the vagina, is that of the oviduct leading from the rounded, flattened nidamental mass.

The only other form of the family Duvauceliidae with a glans approximating the shape here described for *Duvaucelia festiva* is *Tritoniella* Eliot, 1907. *Tritoniella sinuata* Eliot has a cylindrical glans expanding into a flat disk from which rises a conical point. The related species *T. belli* Eliot seems to have a small pointed conical glans, confirmed by Odhner (1926, p. 41).

As has been shown herein, and further on, the shape differs decidedly in other Pacific duvaucelias from *D. festiva* and from each other, the new species *D. gilberti* alone resembling *D. festiva*. Manifestly the shape of the glans cannot be taken as a generic character any more than the presence of a gastric girdle or armature.

Odhner called attention to the shape of the glans in the Duvauceliidae which may be: (1) short conical; (2) long conical to flagelliform; (3) widened and flattened. He used this character for subgenera of *Duvaucelia*.

*Systematic relationships.* The most important characteristic of *Duvaucelia* is the presence of a girdle of chitinous plates, resting upon a strong band of circular muscle fibers, at the pyloric end of the stomach. The frontal veil bears a number of simple or slightly ramified digitations, and at the outer angle or slightly below it on either side is a longitudinally grooved, oral tentacle, (not mentioned by Vayssi re or shown by him, 1901, pl. 6, fig. 1). The liver is divided into a large posterior portion and a quite small anterior lobe, the wide ducts from each opening independently into the pyloric region of the stomach in front of the armature.

In Vayssi re's account, 1879, the magnification of plate 7, figure 96 is given as  $\times 25$ . In 1901, when the same figure was reproduced, no statement in the text was given as to the actual dimensions of the gastric plates and manifestly nothing can be concluded from the figure.

Bergh (Beitr. z. Monog. d. Gattung *Marionia* Vayssi re, 1883, page 314) gives the number of the plates as 77, 57, 48, and 44 in four different specimens of *M. quadrilata* (Schultz). Length of plates mostly 0.6 to 0.9 mm. long, height 0.4 - 0.5 mm. Two plates at left, together, larger than the others. Behind the girdle is a short, smooth area leading into the intestine on the left and above, *behind into the short, main bile duct*. Typhlosole fold about 2 mm. in height, the diameter of whole intestine 2-3.5 mm., behind 2-1 mm. The small lobe of liver sends its duct into stomach *in front of the girdle*.

In *Duvaucelia festiva* the gastric plates are about 0.3 mm. in length (0.27 to 0.30 mm. in one slide) and their height about 0.1 mm., their thickness midway of height about 0.03 mm. The cuticular thickness at the top of the folds reaches 0.036 mm. and thins away on the sides of the same down to 0.002 mm. near their bases. This is the general thickness of the cuticle in the remainder of the girdle except at the summits of the ridges and in the ciliated groove beside the typhlosole. In this species the plates are fewer, 18-20, and do not form a complete circle around the pylorus though the special musculature of this region does so. They are not as large or as heavily cuticularized, in general showing a lesser development as a grinding organ than those of other species here described.

*Sphaerostoma undulata* O'Donoghue, 1924, pages 3-6, without doubt is identical with *D. festiva* (Stearns) so far as coloration and markings go. The details of the gills are somewhat different, two simply pinnate plumes united at the base of each, rather than bipinnate ones. The frontal veil is described as not bilobed, and bearing 17 long, thin cylindro-conical projections rather than eight to ten as in *D. festiva*, but two on one side and three on the other are described as arising from a common base (branched single papillae ?) which might reduce the actual number to 14.

The radula as figured by O'Donoghue is essentially the same.

The description of the masticatory margin is not detailed enough for comparison, nor are any details given of the gastric armature or of the reproductive system.

*Tritonia reticulata* Bergh, 1881, as described in detail by him in the second of his Beiträge zur Kenntniss der Japanischen Nudibranchien, agrees in all essentials with *Duvaucelia festiva*. This is especially true of the characteristic markings of white lines on the notum which are usually retained in preserved material. The radula and mandibles are likewise in substantial agreement.

Bergh's specimen was collected by Dr. A. von Roretz, at the time a professor in the Medical School in Nagoya, and sent to the Vienna Natural History Museum. Apparently the single specimen came from southern Japan, and no record exists of this species being taken later. It is a most interesting example of the wide distribution on both sides of the North Pacific, shared with a number of other nudibranchs.

*Dimensions.* Living specimen, largest taken, measured while crawling actively, 45.5 mm. in length, 6.3 mm. in maximum width, and 7.7 mm. in maximum height, foot length approximately 40 mm., rhinophore height about 6 mm. Same specimen fixed: 21 mm. in length, 7.3 mm. in width, 6.2 mm. in height.

*Habitat.* Monterey Bay; fairly common near low tide limits under overhanging rocks among hydroids, sponges, especially near Point Pinos. It has been taken from San Diego Bay region to Vancouver Bay. One specimen collected off White Rock, Hecate Strait, 20 fathoms, by W. F. Thompson, 1915. Without doubt it will be found farther northward.

### *Duvaucelia exsulans* (Bergh)

Plate 30, figures 9, 10; plate 39, figure 7; plate 43, figures 20-26;  
plate 44, figures 3, 4; plate 45, figures 9-13

*Tritonia exsulans* BERGH. 1894. Bull. Mus. Comp. Zool. Harvard, vol. 25, no. 10, pp. 150-152, pl. 3, figs. 11-12; pl. 4, fig. 6. Off Año Nuevo Point, California in 43-48 fms. O'DONOGHUE, 1921. Nudibr. Moll. Vancouver Island Region. Trans. Roy. Can. Inst., Toronto, vol. 13, pt. 1, pp. 152-154, pl. 1, figs. 4-6. Departure Bay, dredged; Swiftsure Shoal, 23 fms.

LIVING SPECIMEN. (Pl. 39, fig. 7).

The specimen for this illustration was secured from a Chinese fisherman at Monterey, on June 12, 1893, having been taken by him in deep water on rock-cod fishing grounds. It was but slightly injured and slowly revived on being placed in fresh sea water. The general form of the body was somewhat prismatic; its length when not quite fully extended was 50 mm., its greatest breadth was 16 mm., and its greatest height 15 mm., the last two measurements being taken 7 and 14 mm., respectively, behind the rhinophores. Foot length 40 mm., width 17 mm.

The *body* was nearly square in cross section, its height and width being nearly the same throughout its length. In front it is abruptly rounded, its longitudinal profile

is high in front, sloping gradually forward from the highest point, and more rapidly backward to the tip of the short tail, the back being but slightly arched and quite smooth.

The *veil* is broader than the back and indistinctly bilobed, and bears a single series of some 26 low tubercles, each outer angle being modified into a short, auriculate, tentacle-like process. The margins of the back bear a series of low branchial tufts of varying size which, becoming rudimentary, continue well back toward the top of the tail. In front the marginal line continues forward up the sheath of the rhinophores.

The *color* of the dorsum is a deep rose pink (pl. 39, fig. 7), the frontal veil and the sides considerably lighter pink. The tubercles of the frontal veil are white, the margin of the foot, the margins of the dorsum, and the edge of the rhinophore sheath bear a narrow line of white. The foot is light yellowish pink in front, deepening toward the tail. Branchial and rhinophore plumes red-brown in color.

#### PRESERVED SPECIMEN

The above described specimen, preserved in alcohol, shows a body form well retained, though considerably retracted. The length was reduced from 50 mm. to 39.6 mm. by the chromic acid alcohol solution used; dull gray-green in color. (Pl. 30, figs. 9, 10.)

*Dorsum* nearly flat, covered with small tubercles, otherwise smooth. The velar expansion is shortened by contraction, the outer angles modified into tentacle-like processes, short and strongly contracted. The margin bears 26 low, contracted tubercles. *Mouth* opening inflated.

The *foot* is somewhat broader than the dorsum, its margins but slightly set off from the sides of the body which are nearly vertical, and the dorsal margins do not overhang them laterally. The foot is rounded in front, its anterior margin is bilabiate, the groove dying away laterally. Length 35.1 mm., width 12.3 mm.

The *branchial plumes* are arranged in an undulating line, seven large tufts stand at a slightly higher level than eight intermediate sized ones alternating with them. In the intervals between these are some 15 smaller tufts, likewise alternating, many being but rudimentary. The dorsal lateral ridge also continues forward to the outer margin of the rhinophore sheath.

The *reproductive openings* are midway of the height of the side below the second plume of the largest series. Three distinct openings are present, 11 mm. posterior to the anterior tentacle margin. The male opening in front and the female behind, of equal size; below and of one-half the size is the gland-duct opening.

A short distance behind, 4.5 mm., opposite the interval between the third and the fourth tufts, are the anal and renal openings, closer to the dorso-lateral margin, the former upon a short, cylindrical papilla, the minute renal opening just above it.



The *rhinophores* are well out toward the margin of the back, each surrounded by, and retractile within, a low sheath with a smooth margin. The rhinophore stalk is stout, prolonged above to a blunt apex formed by the oblique tapering of its front and sides, its rear face being nearly straight. Around this tapering portion are borne some 20 small, erect, bipinnate plumes, the hinder ones adnate to the shaft which extends above their tips.

The *eyes* are invisible from the exterior, located closely posterior and lateral to the rhinophores, imbedded in the integument. The lens is quite large and pale amber, the cup of black pigment, at its distal end, shallow.

Ten specimens of the same species were dredged by Dr. Tage Skogsberg in Monterey Bay in 1932 and were kindly turned over to me for study. They had been killed in formalin and afterward preserved in alcohol. Their general characteristics agree with those of the earlier specimen. In size, as preserved, they range in length from 21.7 mm. to 65.6 mm.; the width and height being nearly equal, each specimen ranging from a maximum width of 6.6 mm. and height of 5.5 mm. in the smallest, to 22.0 mm. in width and 22.7 mm. in height in the largest, so that the body is nearly square in cross section throughout.

The *frontal veil* is strongly contracted in all the specimens, and bears some 12 to 16 rounded knob-like tubercles, seven on each side of the median line, toward which, usually, they seem to decrease in size. The number is much less than the 26 found in the first specimen, and more than the eight to nine found by Bergh in *T. exsulans*. At the outer end of the veil, or, in some specimens, slightly below the line of its marginal tubercles, is a short, blunt, auriculate tentacle, its outer face deeply grooved throughout nearly its whole length.

Two additional specimens of this species collected by Prof. F. W. Weymouth near Petersburg, Alaska, in about 20 fathoms were also studied. The largest of these measured 80 mm. in length, 23 mm. in maximum width, and 23 mm. in maximum height; the smaller 62 mm. in length, 25 mm. in maximum width, and 25 mm. in height.

The general features of these were very similar to those from Monterey Bay. The frontal veil in the largest specimen has about 20 low tubercles or very short papillae on its margin. In each about 30 gill plumes were distinguishable on the dorsal margins of either side. The smaller specimens were poorly preserved.

*Mandibles.* (Pl. 43, figs. 20-26.) The pharyngeal bulb is of a nearly spherical form, somewhat depressed, entirely white in color, slightly longer than wide and high. In a specimen of 49.1 mm. total length the bulb measured 13.7 mm. in length, 11.5 mm. in width, and 10.6 mm. in height. This proportion of total length to bulb length of 3.7 to 1 holds very closely in all the specimens so measured, though the total length of the animal is much more variable, owing to contraction at death, than is the bulb length. The lining of the short, wide, mouth tube is colorless, as are also the cavity of the bulb and the oesophagus leading from it.



The mandibles are strong, light yellow in color, darker yellow to brown at the masticatory margin. Their form is best indicated by the figures 20, 21, 22 of plate 43 made from the mandibles of the first Monterey specimen. United, the two mandibles form a long ellipse in general outline: strongly convex in the front and in the mid-region near the inner margin, becoming less so laterally and posteriorly, and slightly concave in front of the hinge region and near the lateral margins. There is a concavity at the base of the reflected masticatory margin along its posterior half.

The free *masticatory* process is short (pl. 43, fig. 23), not extending back farther than the mandible's posterior margin. The length of the single mandible, from the upper anterior border above the hinge, to the lower posterior margin, measured along the curvature of the anterior face, is 35 mm., its maximum width from inner to outer margin is 10 mm., the proportion of width to length being 1 to 3.5 in this the Weymouth specimen, 1 to 3.4 average in the Skogsberg ones, and 1 to 3.4 in the first Monterey specimen.

The upper portion of the masticatory margin is broken and worn away through use, leaving an irregular oval space between the two margins below the hinge, the lower third only of the margin being relatively uninjured. The outer edge of the margin below the injured area is reflected outward as a ridge which becomes higher and more prominent toward the end of the median third of the length of the margin. The uninjured portion, and especially that of the masticatory process, shows on its curved inner surface four oblique rows of large conical denticles (pl. 43, fig. 23), bounded externally by a low smooth edge. Each row runs diagonally across the margin, some 14 denticles being present in each oblique row as it passes across the zone. Each denticle is the summit of a nearly hexagonal pyramid which is prolonged into a low conical point directed obliquely forward and downward toward the anterior edge of the marginal zone. The largest of these measures about 0.03 mm.  $\times$  0.021 mm. externally. They are succeeded by a series of small, irregular, flattened, plate-like markings, becoming rapidly obscure and dying away behind.

The *radula* (pl. 43, figs. 24, 25, 26) is light yellow in color, broad and quadrangular in outline, about 8.5 mm. square as mounted, with a deep median groove. Forty-four to 55 rows of teeth are present, the first 20 to 30 rows being worn away and incomplete in the lateral rows, the remainder seemingly complete. A broad median tooth in each row is flanked by from 64 to 82 laterals of uniform type, the first lateral on either side of the median alone being strongly modified in shape from the remainder. In the specimen of 39.6 mm. length as preserved, 44 rows of teeth were present, the 28th row having a formula of (64·1·1·1·64), the 34th (67·1·1·1·67), and the remaining rows having approximately the same number.

The counts given by Bergh (1894, p. 151) may be expressed by the formula 39·41 (61·64·1·1·1·61·64), while O'Donoghue (1921, p. 153) gives 45·52 (60·64·1·1·1·60·64) for specimens studied from the Vancouver region. With these results our own formula of 44·55(64·82·1·1·1·64·82), is in practical agreement. In 1948 an additional specimen was dissected and carefully studied. The radula formula was 47(76·1·1·1·76).

Baba's count of 65 (75-95·1·1·1-75-95) for his Sakhalin specimen does not differ materially.

The median tooth (pl. 43, fig. 24) has a somewhat rectangular base, its anterior margin rounded at the angles, and with a broad median notch. The posterior margin is nearly straight, save for a small median rounded projection, its angles sharply defined. The median cusp is strong and broad, its posterior margins slightly concave as they slope rapidly to the short blunted tip which extends beyond the posterior line of the base. The anterior face bears a wide shallow groove which is prolonged forward and downward into the median notch of the base. Into this depression the cusp of the preceding tooth fits. The lateral cusps are smaller, short and blunt, their tips inclined slightly toward the median line in many cases. The median posterior face of the central cusp is prolonged downward below as a broad ridge in the median line to the base, and often projects beyond and above the posterior margin of the base as a rounded mass. In the specimen of 39.6 mm., measurements of total length and width of several median bases are:

	<i>Length base</i>	<i>Width base</i>
Oldest median	0.156 mm.	0.255 mm.
Twenty-fifth median	0.165 mm.	0.276 mm.
Fortieth median	0.168 mm.	0.276 mm.
Another median	0.195 mm.	0.225 mm.

The first lateral (pl. 43, fig. 24) is of the peculiar form characteristic of most of the Duvaueliidae. It is longer than the median tooth, massive, somewhat prismatic in form. Its base is curved inward at its posterior end. The upper surface presents a flattened, roughly triangular form, rounded in front and broadest behind, where it is prolonged obliquely upward into a strong thickened cusp. Its inner margin overlaps the outer posterior portions of the median tooth. In length it ranges from 0.192 mm. in the oldest to 0.24 mm. in the 40th row.

The remaining laterals (pl. 43, figs. 25, 26) are strongly compressed elongated hooks of quite uniform shape, and varying but little in height, save for the outermost four to six which decrease rapidly in size. Midway of the row on either side, they reach a height of 0.345 mm. The second lateral (pl. 43, fig. 25) is shorter and stouter (0.225 mm. in height) than the outer ones, and the next succeeding laterals rapidly graduate from it to the more slender typical form.

*Habitat.*

Bergh, collector:

Two specimens, March 12, 1894, 43 fms. off Año Nuevo Point, California,  
122°24'W. Long., 37°5'N. Lat.

One specimen, May 3, 1888, 48 fms., 113°13'W. Long., 26°14'N. Lat.  
Approximately off Punta Santo Domingo, Lower California.

O'Donoghue, collector:

Two large and three small specimens dredged on Swiftsure Shoal in 23 fms. Vancouver Island Region, 1921.

MacFarland collection:

One specimen, living, from rock-cod banks off Monterey Bay, California, June 12, 1893.

Ten specimens dredged by Tage Skogsberg, Monterey Bay, 1932.

One specimen dredged by A. Sorenson in 1941 from 50 fms. off Monterey.

Two specimens taken off Petersburg, Alaska, F. W. Weymouth.

Baba, collector:

One specimen taken at Sakhalin, Japan (Karafuto), Col. T. Urita.

#### EXTENDED ANATOMICAL DESCRIPTION.

*Alimentary system.* The paired salivary glands lie laterally to the dilated oesophagus, their ducts passing forward on either side and through the nerve ring, close in front of which they open into the dorsal cavity of the pharyngeal bulb.

The oesophagus emerges from the median antero-dorsal surface of the pharyngeal bulb, is encircled by the central nervous system, and dilates broadly into a thin-walled sac, 5 mm. in diameter, which passes backward to the left and downward; narrowing somewhat it passes toward the right side, makes an abrupt angle backward, and courses in the median line in a shallow groove of the liver. Curving to the left and forward and upward, it partly encircles the right anterior lobe of the liver. Passing obliquely upward, its wall thickens forming the gastric girdle, a thick-walled cylindrical segment of the stomach bearing on its inner surface a series of thickened cuticular plates. (Pl. 45, fig. 10.) Immediately in front of this girdle the stomach receives through its dorso-anterior wall a wide duct from the right anterior lobe of the liver, and close behind it a similar wide duct from the major left and posterior hepatic mass.

The liver presents an incompletely separated right anterior lobe, continuous in part with the larger left and posterior lobe. (Pl. 45, fig. 10.)

Beyond the gastric girdle, the stomach narrows abruptly into the intestine which passes diagonally on the dorsal surface to the left, then loops to the right and backward to the external anal opening. Inclosed within this intestinal loop and lying in part above it are the pericardium, heart, and kidney.

Immediately in front of the beginning of the intestine, the pyloric stomach wall is thickened to 3.5 mm. in width, diameter 5.5 mm., by the appearance of a band of circular muscles completely surrounding it. The inner surface presents some twelve to sixteen prominent, longitudinal plates or ridges corresponding in length to the width of the zone of muscle (pl. 45, fig. 11). In front of and behind the ridges is a narrow, entirely smooth translucent strip, beyond which, in the stomach, are several more or less irregular folds of the lining converging toward it.

The epithelium (pl. 45, fig. 12) of this pyloric girdle bears a strong yellowish cuticle which is thickened greatly at the middle of the plates and thins away at the bottom of the grooves between them. In the contracted condition of the girdle the individual

plates are arched sharply inward and project as strong ridges forming a grinding mechanism. Different degrees of contraction, and consequent elevation of the ridges, may be found in different specimens so that their respective heights are variable. While most of these ridges are continuous throughout the width of the girdle, there are several shorter ones interspersed between them. The height of an average ridge is 0.465 mm., and the thickness of its cuticle at the crest reaches 0.03 mm. and does not vary greatly from this throughout its length. (Pl. 45, figs. 11, 12.)

Two of these ridges, located on the ventral side of the band, are much higher than the remainder and extend entirely across the girdle, anteriorly leading into the wide opening of the liver, and posteriorly merging with the typhlosole folds of the intestine. (Pl. 45, fig. 12, *a*, *b*.)

The cuticle at the summits of these two folds and the platelets, is at least twice as thick as the height of the epithelium producing it. It thins away, in some measure, in the grooves but does not disappear, so that the cuticular lining is a continuous layer throughout the extent of the girdle, save for the bottom of the groove between the two highest ridges. As a result, the plates are not separable as in *Marionia* species.

The grooves between these higher folds are lined with ciliated columnar epithelium and form an open channel for the hepatic secretions to pass from the pylorus into the intestine. (Pl. 45, fig. 12 at *c*.)

Externally the girdle is bounded by a thin adventitia layer covering the thick layer of circularly disposed muscle fiber. Within the muscularis is a felt-work of connective tissue bearing vascular channels. This connective tissue is greatly thickened beneath the plates of the girdle forming the elevations upon which they are borne.

When the circular muscle band is contracted, the plate-like ridges evidently become higher. Width of No. 22 platelet midgroove to midgroove 0.75 mm.; height of No. 22 platelet crest to outer adventitia 0.39 mm. Shortest (narrowest platelet No. 6) width 0.18 mm., height 0.24 mm. Widest platelet No. 21 in section .945 mm. (Pl. 45, fig. 12.)

The intestine lining is thrown into numerous, low, longitudinal folds and a larger conspicuous one, the typhlosole, which continues around the anterior loop and terminates in a short free prolongation some distance in front of the anus. The typhlosole is attached to the intestine wall by a narrow isthmus, and expands distally into a nearly cylindrical, longitudinally fluted structure which nearly fills the intestine lumen, as is shown in the outline figure on plate 45, figure 13. It is essentially a reduplication of the columnar intestinal epithelium borne upon a highly vascular tunica propria of connective tissue, and provides a very large increase of the digestive and absorptive epithelial surface.

All the specimens of this species dissected by me agree in external features and in internal characters. How Bergh could have overlooked the pyloric armature of the stomach is difficult to understand, since this is the feature which differentiates the genus *Marionia* Vayssière from *Duvauccelia*, and it is one to which he had paid special attention in his anatomical study of *Marionia*, 1883. It is indubitably present.

While Vayssière's type species, *Marionia berghii* Vayssière (= *blainvillaea* Risso) has the papillae of the frontal veil somewhat longer and with short ventral branchings, this is not found in many other species of *Marionia*, and cannot be considered an essential character, while the gastric armature is of fundamental significance. In none of the descriptions of this armature is it clear whether the belt is made up of separate teeth, or whether they are united below in a continuous band by the common chitinous cuticular investment of the epithelium, nor is it anywhere clear that the other genera, *Duvaucelia* especially, have anything resembling this band.

*Reproductive system.* The ovotestis covers the dorsal surface of the liver in a thin layer in all specimens examined. None of them were taken at the height of the breeding season so that the reproductive organs were not as large or as conspicuous as would be found at such times. The ovotestis contained only immature ova and spermatozoa. This was true of all sizes. (Pl. 44, figs. 3, 4.)

The anterior *genital complex*, as a whole, is much smaller than in the other species of *Duvaucelia* studied. The body wall of this animal is thick, its texture becoming quite loose as the inner layers are reached and the complex is enmeshed in this network of tissue, its outer part being imbedded, as it were, in the body wall. Upon the posterior border of the complex is the irregularly coiled *hermaphroditic ampulla* expanding from the slender hermaphroditic duct. Here it divides into the *vas deferens* and the *oviduct*, the latter having entered the nidamental gland mass. The length of the vas deferens is 7 mm., 0.4 mm. in diameter. It is lined by ciliated epithelium with very long cilia throughout, and does not show any distinctly glandular or prostatic portion whatever. Near the glans penis the strong muscular wall has five to eight longitudinal folds covered by high ciliated cells, cilia twice as high as the cells.

*Preputium.* At the anterior end of the complex, as seen from the inner surface, is a broad, circular disk 6 mm. in diameter, from the center of which a white tube, the spermatic duct, emerges and passes backward and slightly downward. This disk is the proximal end of the preputium, a conical sac dilated in its proximal portion for the reception of the *glans*, and distally contracting rapidly as the external opening is approached. The base of the *glans* is coextensive with the proximal end of the preputium and arises from it as a rounded mass of a somewhat hemispherical shape about 2.35 mm. in diameter, 3 mm. high.

Upon its extremity it bears a well defined *ridge* surrounding an oval area, 1.8 mm. in diameter. The contour is somewhat reniform rather than circular and is directed downward and outward. The margin of this ridge is slightly reflected outward and the thin edge thus formed bears a single series of minute, thorn-like spines about 40 in number. The included surface bears a ciliated epithelium; it is slightly concave but rises in the center at the opening of the vas deferens.

On the dorsal side of the *glans* mass is a *groove*, lengthwise of its surface, well defined at the proximal end and terminating before the margin is reached. A similar groove is borne on the anterior face. The exact shape of the glans varies with its degree of distension or contraction. (Pl. 44, fig. 4.)



Nothing similar to the armature here described has been seen in any of the Duvauceliidae by previous observers. Bergh dismisses the organ with the brief sentence: "Die vordere Genitalmasse sehr wenig entwickelt." From this it is evident he did not dissect it at all. O'Donoghue states merely that the penis is short and subconical.

The *vagina* passes inward close behind the penis above the oviduct, curves upward, then downward on the inner posterior face of the *adnexed genital mass*, dilates into a small, empty ellipsoid sac, the *spermatheca*, terminating blindly above the small gland complex. The vagina is 8.5 mm. long, 3 mm. inclosed in the body wall; spermatheca, 3 mm. in length.

The external opening is crescentic in outline, the convex margin dorsal, bearing numerous grooves leading inward. The concave ventral margin is formed by a rounded mass with but few grooves on its upper surface. Opening from the top a roomy space is disclosed; on the anterior side is the male aperture, 3.8 mm. long, dorsally is the broad *vaginal* aperture, and posteriorly, below, that of the gland complex. (Pl. 44, fig. 3.)

The *central nervous system* was taken from the Monterey specimen of 1893, stained in paracarmine, and studied in glycerine in sunlight before a permanent mount was made. (Pl. 45, fig. 9.) The following notes were made:

The right pleura is torn. The cerebral ganglion is reniform in contour, broadly united to the pleura by the middle of great curvature. From the antero-dorsal surface above the middle of the crescent, a stout nerve, *C. 1*, arises, giving off a smaller branch which at once bifurcates. Below this, and equal to it in diameter, is *C. 2*, which bifurcates into two equal trunks.

A strong trunk, just external to *C. 2*, arises and bifurcates farther out; this is *C. 3*. *C. 4* arises from the lateral lobe of the crescent, bifurcates still farther out. *C. 5* arises from the posterior outer face of the cerebral ganglion close above the appearance of the cerebro-pedal connective. It passes outward and trifurcates close to the origin.

Accompanying *C. 5* closely is a slender nerve from the pleural ganglion which arises from the outer anterior face above the otic vesicle (statocyst). It passes forward and outward across the pleuro-pedal and cerebro-pedal connectives and thence laterally in close connection with *C. 5*. (Pl. 45, fig. 9, *pl. 1*.)

Above this and slightly behind it, a second quite slender pleural nerve (*pl. 2*) arises. It arches backward over the root of the large nerve and accompanies it.

A large nerve from the outer mid-face of the pleural part of the cerebro-pleural ganglion (shown as *pl. 3* on fig. 9, *pl. 45*), passes outward and backward and soon divides into four strong equal limbs.

Each pedal ganglion gives rise to three pedal nerves, anterior, median, and posterior.

These additional notes are taken from the study of sections. The eye, invisible from the exterior, is imbedded in the looser layers of the integument back of the rhinophore. Close in front of the eye is a delicate nerve which sends a very slender branch to it as the optic nerve and continues to the integument. The lens is quite large and pale amber, the cup of black pigment at its proximal end is quite shallow. A large ganglion



on the vas deferens is found as it narrows before joining the oviduct and hermaphroditic duct at the latter's branching. The ganglion almost encircles the duct.

**Duvaucelia gilberti** MacFarland, new species

Plate 30, figures 1, 2; plate 43, figures 27-36; plate 44, figure 5; plate 45, figure 6

LIVING SPECIMEN.

*Body* very plump, subquadrilateral, somewhat depressed, wider than high, prolonged anteriorly into a crescentic, slightly emarginate *frontal veil* bearing short conical processes (length of longest ones 2.5 mm.; width 1-1.5 mm.) numbering 20 to 24, but apparently variable as they are of varying sizes, some appearing to be in different stages of regeneration. Outer margin of veil thickened and rolled into a peculiar grooved tentacle-like structure, the inside of groove directed downwards. Mouth an elongated opening.

*Foot* smooth, slightly wider than the dorsum, its anterior margin rounded, undivided.

*Gills.* Margins of the dorsum undulating, bearing a closely set series of low bi- or tripinnate branchiae alternating in size large and small; becoming smaller posteriorly and rudimentary in the tail region. There are about 30 in number of which 16 are large, richly branched from a stout conical stalk, as wide as high. The stalk bears two or three branches, each giving off three to six branches bearing lamellae alternately arranged. Some are prolonged and subdivided, hence quadripinnate. Anterior end of the dorsal margin prolonged to the outer side of the rhinophore sheath and uniting with it as a low ridge.

*Eyes* not visible, under the integument.

*Rhinophores* surrounded by a high sheath with a smooth, thin margin, irregularly crenulate. The strong conical stalk bears a circle of bipinnate plumes, free except at their bases, the posterior one being adnate to the stalk.

*Mouth*, a median longitudinal slit surrounded by inflated lips.

*Anus* situated somewhat behind the mid-length of the body upon the summit of a short, conical papilla close beneath the right dorsal margin of the back. Some 2 or 3 mm. in front of it at the same level is the minute renal opening.

The *reproductive openings* are about one-third of the distance forward from the anus to the angle of the veil, close together, and more or less united in a common, crescentic depression upon a slightly elevated area midway of the height of the side at that point.

A Monterey specimen was used for study of mandibles and radula.

*Mandibles.* The large pharyngeal bulb is somewhat short, ellipsoidal in form, but slightly longer than wide and high and approximates one-fourth the total length of the body, 23.6 mm. long, 21.4 mm. wide, 18 mm. maximum height. Its superior surface is elliptical and somewhat concave, the antero-ventral surface convex with the large elongated mouth opening in its middle. Laterally the mandible margin forms a prominent, sharp ridge in front, curving downward and backward the full length of the bulb. The short and wide mouth tube is deep orange, the cavity of the pharyngeal bulb is yellow, turning darker toward the mandibles and lighter in the radula region. In one specimen from the Seale collection, the mouth tube and bulb cavity are colorless.

The pale yellow ventro-anterior *mandibles* (pl. 43, figs. 27-36, group *D*) strongly curved from above downward and backward, the hinge region is curved forward, the hinge itself scimitar-shaped, long and narrow, the anterior surface lateral to it, quite concave. The median part of the mandibles flanking the opening is strongly convex and much thickened, becoming less so posteriorly, while laterally they thin away and are flattened. (Pl. 43, fig. 28.)

The breadth of the two joined mandibles with their cutting margins in contact is nearly equal to their length, and, in consequence, the breadth of a single mandible is close to one-half its length; 26.5 mm. wide cojoined, anterior to posterior edge a straight line of 26.5 mm., length on curve 45 mm. The masticatory process is quite short, extending not quite as far as the posterior border of its mandible, from which it is separated by a narrow triangular space partly bridged by a thin, web-like, chitinous membrane.

The masticatory margin is much worn and broken in its upper anterior portion, less so in the lower, posterior part. At no place, however, does it show an armature of short denticles such as is usually formed in other species, the margin in this case being entirely smooth.

*Radula.* The pale-amber radula is broad, the width and length nearly equal, worn away as usual laterally at the anterior end, 19 mm. long, 18 mm. wide. It has from 43 to 67 rows in the specimens examined, and the number of teeth in each half row ranges from 60 to about 112. Two formulae are 43 (60·1·1·1·60) and 67 (112·1·1·1·112); a composite 67 (109·1·1·1·109).

The median tooth is quadrangular in outline, its angles rounded, the anterior margin with a deep, rounded, median notch which is continued backward as a groove on the upper surface toward the median cusp. The cusp is broad and short, directed obliquely upward and backward, its tip scarcely reaching the plane of the slightly concave hinder margin of the base.

Below the tip the throat of the cusp is prolonged downwards as a median ridge, lateral to which the posterior face on either side slopes abruptly downward and backward. This median ridge terminates as a rounded projection upon the mid-line of the base, directly opposite fitting into the median notch upon the anterior face of the succeeding median tooth.

Lateral to the median cusp on either side is a deep longitudinal groove beyond which a rounded eminence bears an imperfectly developed lateral cusp, or its posterior border may be straight and ridge-like with scarcely an indication of a cusp. The base length of the median tooth ranges from 0.225 mm. in the 20th row to 0.240 mm. in the 40th, the corresponding widths being 0.225 mm. and 0.285 mm. (Pl. 43, fig. 30.) Plate 43, figure 33 shows a drawing of a median tooth cut through the inner portion of the lateral groove.

The first lateral tooth somewhat resembles an oblique half pyramid, the low hook-like apex situated near the hinder end being inclined toward the median tooth. The superior, outer face is nearly flat, sloping laterally. The inner face is excavated considerably and overlaps the margin of the median tooth. The base is somewhat L-shaped, thickened at the posterior margin. While not conspicuous, a general similarity between the irregular first lateral and the more typical second one may be recognized as seen in figures 29 and 32 of plate 43.

The second becomes more compressed and, while likewise inclined toward the median line, it bears a strong hook with a long, basal portion (pl. 43, fig. 29). The succeeding laterals become still more compressed, the hook more erect and slender, the base narrower. The full height of the hook, about 0.37 mm., is reached in about the eighth lateral, length of base 0.246 mm., and from there on outward the size remains uniform, except for the outermost fifth or sixth, there rapidly decreasing in size, becoming quite slender and much more oblique, making an angle of about 40 degrees with the plane of the base, rather than nearly a right angle. (Pl. 43, figs. 34, 35.)

Considerable variation in the extent of development of these cusps may be seen in different specimens, and even in the same radula. In one specimen this was especially striking. In the first 38 rows, the single median cusp, prominent in other *Duvauceliidae*, was replaced by two blunt cusps, close together and separated by a narrow groove which widened anteriorly into the median notch. (Pl. 43, fig. 29.) These cusps have the form of three-sided oblique pyramids, the median face formed by the prolongation of the side of the central groove, the posterior face nearly vertical, and the superior face sloped obliquely forward and outward. The tips converge and in some teeth were nearly in contact. By elimination of the median groove through fusion of these two cusps, the single median one characteristic of other species would be formed. No trace of the lateral cusps found in most *Duvauceliidae* can be detected in this radula.

In the younger portion of this radula, from the 40th row on, the structure of the median tooth becomes greatly modified. The two half cusps approach and fuse, a faint line only indicating the plane of union, the tips becoming less and less prominent. Their front margin forms a continuous line or ridge extending nearly across the dorsal surface of the tooth, behind which the surface slopes backward gradually, in front dropping downward more rapidly. In the very young teeth the median presents a flattened upper surface throughout, with no signs of cusps or ridge. The base also becomes more irregular and asymmetrical in outline.

In the same specimen as the one with the anomalous median teeth, the first lateral of one side (the right) decreases in size rapidly from the 38th on, quickly becoming a

mere rudiment wedged in between the postero-lateral face of the median and the enlarged second lateral which progressively takes on the form of a heavy thickened hook.

The *color* of the dorsum of the living animal is a deep rose pink. Gill and rhinophore plumes are translucent, yellow to pale brown. Outer side of gill stalks sprinkled with fine white, continuous as a narrow line which borders the edges of the body, the veil processes, rhinophore tip, and sheath. The white line is also continued down the front side of the head upon a slight ridge extending to the outer corner of the veil.

*Dimensions.* The total length of the living Monterey Bay specimen while crawling freely was 107 mm., its maximum width 50 mm., and maximum height 47 mm.; rhinophore height 6.5 mm.; largest gill stalks 4 mm. long by 4 mm. wide. After preservation the same specimen measured 82.5 mm. in length, 33 mm. in width, and 20.6 mm. in height. The foot measured 76 mm. in length, and 26 mm. in maximum width.

The dimensions of preserved specimens vary widely owing to the varying degree of contraction or relaxation of the musculature. In all, however, the width of the body is distinctly greater than the height. The three best extended specimens collected by Dr. Gilbert off Point Reyes measured respectively: 90 mm. length by 50 mm. width by 30 mm. height; 120 mm. length by 45 mm. width by 25 mm. height; 110 mm. length by 35 mm. width by 22.5 mm. height.

*Habitat.* Monterey Bay, one specimen taken by a Chinese fisherman on August 6, 1898; out from Point Reyes, immediately north of San Francisco, five specimens were collected by Charles H. Gilbert while on a fishing trawler; dredged off the entrance to San Francisco Bay in 20 fathoms, two specimens by Alvin Seale of the Steinhart Aquarium of the California Academy of Sciences, May 21, 1931; dredged off San Francisco, by the U. S. S. *Albatross*, four specimens; from the east side of Drakes Bay in 20-23 fathoms, three specimens received from G D. Hanna, November 10, 1950.

#### EXTENDED ANATOMICAL DESCRIPTION.

*Alimentary system.* The oesophagus is 9 mm. wide at the level of the nerve collar and dilates behind rapidly, passing over into the stomach without any marked boundary. On either side it is accompanied by the pale, yellow, posterior salivary gland, a narrow flattened lobulate band widening somewhat toward its posterior end, on the left side terminating in contact with the anterior left border of the liver. On the right side it is longer, following along the right border of the oesophagus downward and terminating below the anterior end of the stomach. This is a large thin-walled sac passing obliquely backward from the left anterior face of the liver in a deep groove in the ventral surface of the latter. Near the median line it bends upward into a deep notch in the right border of the liver and appears on the dorsal surface, narrowing at once into the intestine which curves to the left and forward, then describing a sharp loop and passing to the right and backward to the anus.

Throughout its extent, the stomach lies in a deep groove on the dorsal surface of the liver and is bounded in front by a relatively broad lobe of the ovotestis which ex-

tends transversely across the visceral mass forming its anterior boundary. It was fully distended with closely packed, partly digested food material containing rod-like fragments of alcyonarian skeletons, some reaching a length of 25 mm. In one instance four cylindrical masses were found, each 25 mm. in length and 5 mm. in diameter, light brown in color, and containing a central, slender, rod-like, white axis surrounded by light-brown spongy substance. At regular intervals of about 3.0 mm., the cylinder bore a circle of groups of white spicules radiating in fan-like order from the central axis. Each group is made up of calcareous spindle-shaped spicules, 2 to 2.5 mm. in length, between which much shorter and more slender ones are arranged. Toward the end of the intestine these spicules break up into smaller fragments.

The wall of the stomach is smooth, save for a few, low, longitudinal, probably transitory, folds. At the pyloric end of the stomach its wall is modified into a narrow muscular girdle, 2.7 mm. in width, and its epithelial lining is thrown into about 18 prominent folds which meet in the center when contracted, and nearly occlude the lumen. These folds bear a thick cuticle, especially prominent at their crests, but also continuously lining the depressions between them, save at one place between two higher folds on the ventral side. These two folds arise close to the entrance of the biliary duct into the pylorus and extend across the girdle and into the intestine, where the larger of the two becomes continuous with the typhlosole fold, a high reduplication of the mucous membrane 2.5 mm. in length, which continues well beyond the intestinal loop, and terminates in a rounded, lobe-like, free tip. Lateral to the typhlosole in the intestine are a large number of minor folds which extend through its whole length.

The biliary openings are two in number. The posterior one opens on the inner left side of the pyloric stomach close in front of the girdle by a wide aperture from which numerous ducts ramify to the larger portion of the liver. The anterior opening is immediately in front of the posterior one on the lower left wall of the stomach and leads into a roomy cavity draining the anterior portion of the liver. Into this cavity are directed the two folds which cross the pyloric girdle. The surface of the liver is covered with the thick, pale-yellowish layer of the ovotestis; the liver beneath is brown. No indication of a separate lobe is found in this specimen.

*Reproductive system.* The *ovotestis* varies from 2 to 5 mm. in thickness and extends inward between the lobules of the liver in rounded projections. The only place in which the liver is revealed is at the bottom of the grooves occupied by the stomach and the intestine. Elsewhere it is completely concealed.

The anterior reproductive complex (pl. 44, fig. 5) is a large, somewhat wedge-shaped mass between the pharyngeal bulb in front, the liver behind, and the right side of the body externally. The bulk of the complex is formed by the nidamental and albumen glands upon the top of which, in front, lies the preputium, and close behind it the sac-like vagina.

Upon removal from the body, the outer and lower surfaces are convex, conforming closely to the body wall. The nidamental gland mass is thickened on the right side and thins away ventrally as it extends beneath the pharyngeal bulb; sloping downward



and backward abruptly, it is in direct contact with the oblique anterior end of the liver-ovotestis complex behind.

The white hermaphroditic duct, 1.4 mm. in diameter, passes forward and outward from the ovotestis expanding into the irregularly coiled, long *hermaphroditic ampulla* which lies upon the thinner face of the mass. Its length is about 90 mm.; its quite uniform diameter is 2.5 mm.; its wall is quite thin and smooth and presents a glistening, white appearance. Its distal end passes from the lower anterior face of the complex outward between the lobes of the albumen and nidamental glands and, narrowing rapidly, divides into two short slender tubes. One of these, the oviduct, passes back at a sharp angle into the gland mass and opens into its lumen, the other, the vas deferens, dilates almost at once into its glandular prostatic segment, some 16 mm. in length and 2.8 mm. in diameter. It forms a short loop around the base of the preputium, returning across it and entering nearer its posterior border.

The *preputium* is cylindro-conical in form, tapering from a flattened base to the external opening. It is 10.2 mm. in length, with a basal diameter of 4.6 mm. Its wall is strong and muscular, its inner surface bears low circular ridges, save near the external opening where they become longitudinal.

Within the preputium is the conical *glans penis*, 6.8 mm. in length, arising at the proximal end of the sac as a broad base, 3.2 mm. in diameter and tapering to a minimum diameter of 1.1 mm., then dilating abruptly as a narrow ring with concave sides to a nearly sharp edge of 1.7 mm. diameter. Beyond this ring the glans narrows and terminates in a spherical *knob*, 2.0 mm. in diameter, on the distal surface of which is the external opening of the vas deferens. The whole form of the glans is so regular and symmetrical that its shape cannot be due to local contractions of a simple conical form. As here described, it was found in the best preserved specimen; in all others dissected, however, this peculiar form could be recognized. No surface armature of the glans was found.

Immediately behind the preputium and parallel with it is a thick-walled muscular sac. Its surface shows indistinct meandriform outlines, through an otherwise smooth surface, the external indications of its rugose inner surface. This sac forms the *vagina*, the female copulatory duct. It measures 18 mm. in length and reaches its greatest diameter of 7.6 mm. about midway of its length. The proximal end is rounded and directed downward. From it emerges a slender duct 4.8 mm. long by 0.5 mm. wide, which passes obliquely downward and forward, crossing the vas deferens and expanding into a thin-walled pyriform sac, the *spermatheca*, which is in part concealed between the anterior lobes of the nidamental gland. It reaches 8.5 mm. in length, and is divided by a slight constriction into a distal, smaller part, 2.7 mm. in diameter, and a proximal larger one, 5.5 mm. in diameter. This may, however, be caused by different degrees of distension and not be because of any fundamental anatomical differences.

*Central nervous system.* (Pl. 45, fig. 6.) The cerebro-pleural ganglia are closely fused, the cerebral moiety somewhat crescentic, its rounded tips directed forward and



## PACIFIC COAST SPECIES OF DUVAUCELIA

Radula		Mandibles	Glans	Stomach Armature
<i>D. tetraquetra</i> (Pallas) 50(225 1 225) 57(232 1 1 1 232) 70(224 1 1 1 224) 81(266-312 1 1 1 266-312)  Syn. <i>Tr. gigantea</i> 94(250 1 250)	Bergh O'Donoghue MacFarland MacFarland  Bergh	Mouth tube white. Somewhat helmet shaped, strong ligament. In front, margin of right mandible overlaps left. Cutting edge smooth inside. 80 rows of polygons. Outer edge short, chitinous prisms.	Conical, slightly curved, tip blunt, unarmed.	Pyloric girdle 12-15 low folds or ridges, covered by brown cuticle, thick on the crest, thin between.
<i>D. palmeri</i> Cooper 36(35 1 1 1 35)	Cockerell and Eliot	Masticatory margin 4-6 rows of strong denticles.	Not given.	None found.
<i>D. festiva</i> Stearns 42-57(49-85 1 1 1 49-85)  Syn. <i>Tr. reticulata</i> (1 sp.) 53(94 1 94) Syn. <i>Sph. undulata</i> 87(42 1 1 1 42)	MacFarland  Bergh O'Donoghue	Yellow, shield-like form, strong. One mandible 9 x 3 mm. Cutting margin 3-5 rows pointed denticles.  Bulb long, mandibles 11 mm. long, 8 mm. wide, 3.6 mm. high. No details.	Urn shaped, about square. End truncate, sharp margin, armed; thickened flap at opening.  Not given.	18-26 longitudinal folds in gastric girdle, covered by cuticle.  Not given.
<i>D. diomedea</i> Bergh 73(150 1 150) 38-42(58-60 1 1 1 58-60)	Bergh O'Donoghue	Oral tube brown to red, mandibles yellow, cutting edge 4-5 conical papillae.	Short, conical. Not given.	Not given. Not given.
<i>D. exsulans</i> Bergh 39-41(62-65 1 62-65) 45-52(60-64 1 1 1 60-64) 44-55(64-82 1 1 1 64-82) 65(75-95 1 1 1 75-95)	Bergh O'Donoghue MacFarland Baba	Oral tube white, two mandibles elliptical shaped, one mandible on curve 35 mm. long, 10 mm. wide. Ten to twelve rows polygonal elevations; cutting edge, 4 rows oblique cones.	Rounded mass, 2.35 mm. diameter x 3 mm. high. Extremity oval 1.8 mm. diameter ridge with 40 spines on edge. Groove on dorsal side.	Girdle 5.5 mm. diameter. 12-16 longitudinal ridges bearing cuticle.
<i>D. gilberti</i> MacFarland 43-67(60-112 1 1 1 60-112) composite 67(109 1 1 1 109)		Mouth tube deep orange. Mandibles strong, joined, length and width equal, convex, margin smooth, no denticles.	Conical. 6.8 mm. long, base 3.2 mm. wide, narrows to 1.1 mm., to sharp ring, ends in round knob. 2 mm. diameter.	Girdle 2.7 mm. diameter. 18 ridges thick cuticle.

laterally, the pleural ganglia rounded. In the median plane the right and left ganglia are close together, the cerebral commissure strong and clearly visible.

The pedal ganglia are spheroidal, larger than the cerebral or pleural ones. The relatively long cerebro-pedal and pleuro-pedal connectives are united in a common epineural sheath and are indistinguishable except in sections. The pedal and parapedal commissures, looping around below the oesophagus, are very long, much longer than in the other *Duvauceliidae* from this region. A very delicate sub-cerebral commissure seems to accompany the others, but it is with difficulty distinguishable from their common connective tissue sheath and may be regarded as doubtful.

From the ventro-lateral face of the cerebral ganglia on either side arises a slender trunk, the cerebro-buccal connective, which passes around the beginning of the oesophagus to the buccal ganglia. These ganglia are elongated transversely and lie close beneath the anterior end of the oesophagus as it emerges from the bulb. They are united by a quite short and broad commissure from which a short median trunk extends backward, dividing by a T-shaped branching into two lateral nerves which pass into the oesophageal wall after a short lateral course.

From the anterior lateral border of each buccal ganglion, a very short connective passes outward into the small gastro-oesophageal ganglia from which nerves pass to the salivary glands and their ducts, and backward along the oesophagus to the stomach.

From the outer posterior face of the pleural ganglia a slender trunk arises and passes downward and backward close to the pedal commissures, but separate from them. These unite to form the pleuro-visceral commissure, and give off a branch to the right to the anterior genital complex and other branches to the viscera.

The large olfactory ganglion lies at the base of the rhinophore. It is connected with the cerebral ganglion by a long sinuous nerve from its anterior border. Close below and slightly behind the rhinophore is the small black eye deeply imbedded in the integument. Its very slender optic nerve arises from the antero-lateral margin of the cerebral ganglion.

#### RELATIONSHIPS.

In general appearance *Duvaucelia gilberti* resembles *D. exsulans*, but it presents greater length and a more flattened form, the height and width being equal in most specimens; however, occasionally the width exceeds the height. Both species have numerous velar papillae, and the dorsal marginal gill tufts carried forward to the rhinophore sheath. The color is similar.

A study of the internal structure is necessary to reveal specific differences which are very marked in the reproductive system, less so in the mouth parts.

The pharyngeal cavity and the mouth tube are deep orange in *Duvaucelia gilberti*; the masticatory margin of the mandibles smooth. *Duvaucelia diomedea* has a dark brown-red mouth tube, but denticulate masticatory margins of the mandible, and a denticle-like prominence on the hinder margin of the strong hook of the lateral teeth of the radula. The median teeth of the three are strong and wide, that of *Duvaucelia*

*gilberti*, however, has the central cusp thick and short flanked by quite low, sometimes rudimentary lateral cusps. The dental formulae of the three varies widely, the range in the genus being great.

No pyloric girdle is described for *Duvaucelia diomedea*, but exists in both *D. exulans* and *D. gilberti*.

In the reproductive system of *Duvaucelia gilberti*, the most striking difference exists. The hermaphroditic ampulla is somewhat wider and longer than in the other species, excepting *D. festiva*. It is short and muscular before entering the preputium. The shape of the glans differs markedly from the other forms, having a knob-like termination with a ring at its base. No armature was found. Bergh makes no mention of the gastric armature, nor does he mention the peculiar form of the glans penis.

### Family HANCOCKIIDAE

*Hancockiidae* MACFARLAND, 1923. Journ. Morphol., vol. 38, no. 1, pp. 90-91.

*Hancockiidae* MacFarland, ODHNER, 1936. Mém. Musée Roy. d'Hist. Nat. de Belgique, ser. 2, fasc. 3, pp. 1103-1105.

Body aeolidiform; oral veil prolonged into digitate lobes at the angles, foot rounded in front; cerata non-caducous, forming digitate lobes; rhinophores perfoliate, retractile into sheaths; cnidocysts present in cerata and rhinophore sheaths. Liver ramifying to cerata and rhinophores; a median unpaired salivary gland present; second stomach with cuticular armature.

Oral disk bearing armature of short rodlets, mandibles with denticulate masticatory process, radula narrow, triserial.

#### Genus *Hancockia* Gosse

*Hancockia* GOSSE, 1877. Ann. Mag. Nat. Hist., ser. 4, vol. 20, pp. 316-319. Genotype, *H. eudactylota* Gosse, 1877, (pl. 11) from Tor Bay, England = *Doto uncinata* Hesse, 1872. NORMAN, 1890. Ann. Mag. Nat. Hist., ser. 6, vol. 6, p. 79. GAMBLE, 1892. Ann. Mag. Nat. Hist., ser. 6, vol. 9, p. 378, pl. 17, fig. 3. GARSTANG, 1893. The Conchologist, vol. 2, no. 5, p. 110. On the relation of Hesse's *Doto uncinata* to the genus *Hancockia*. ELIOT, 1906. Journ. Marine Biol. Assoc. Plymouth, vol. 7, no. 3, p. 353, pls. 11, 12. ELIOT, 1910. Monogr. British Nudibr. Moll. (Alder and Hancock), vol. 8, Suppl., pp. 118, 163. ELIOT, 1912. A note on the rare British Nudibranch *Hancockia eudactylota* Gosse. Proc. Zool. Soc. London, p. 770, pl. 85, figs. 1-7. ODHNER, 1914. Beitr. zur Kenntnis der marinen Molluskenfauna von Rovigno in Istrien. Zool. Anz., vol. 44, no. 4, pp. 166-167. MACFARLAND, 1923. Journ. Morphol., vol. 38, no. 1, pp. 65-92, pls. 1-6. PRUVOT-FOL, 1931. Notes de systématique sur les Opisthobranches. Bull. Mus. Paris, ser. 2, vol. 3, no. 8, pp. 747-755. ODHNER, 1936. Nudibranchia Dendronotacea. Mém. Musée Roy. d'Hist. Naturelle de Belgique, ser. 2, fasc. 3, pp. 1103-1105.

*Govia* TRINCHESE, 1885. Rend. R. Accad. Sci. fis. math. Napoli, vol. 24, no. 6, pp. 179-180. TRINCHESE, 1886. Mem. R. Accad. Sci. Ist. Bologna, ser. 4, vol. 7, pp. 183-194, 1 pl. Genotype *G. rubra* nov. Bay of Naples.

*Iduliana* O'DONOGHUE, 1932. Proc. Mal. Soc., vol. 20, no. 3, pp. 146-147, fig. 3. Genotype *Iduliana papillata* O'Donoghue, Gulf of Manar, India. (See Odhner, 1936. Nudibr. Dendronotacea, p. 1104.)

The brief generic description of Gosse, 1877, is as follows:

"Body linear, scarcely palliate.

"Head beneath produced on each side into a broad, flat, many-fingered oral tentacle.

"Dorsal tentacles two, with laminate bulbs, retractile within sheaths.

"Branchiae three pairs, foliate, pinnatifid, infolding, remotely seated on the subpalliate margin of the back.

"Foot linear, grasping."

The generic description was expanded by Eliot in 1910: "Animal elongate. Head with an oval veil, bearing non-caducous, digitate cerata at the sides. The rhinophores bear a few perfoliations and are set in long sheaths. On the dorsal margin are about five lobed processes. Jaws denticulate. Radula triseriate. Liver in three divisions (two entering the stomach laterally and one posteriorly) which give off diverticula to the cerata. Cnidocysts appear to be present. Genitalia unarmed. The hermaphroditic gland, which is formed of many lobules, fills the posterior part of the body."

Described by MacFarland in 1923, the essential characters of the genus seem to be the following: animal elongate, foot narrow, linear, truncate in front, bluntly pointed behind; head with an oral veil bearing broad palmate processes at the sides, rhinophores with perfoliate clavus retractile into campanulate sheaths; dorso-lateral body margin bearing a series of lobed processes, the dorsal papillae or cerata; cnidocysts present in the rounded elevations on the rhinophore sheaths and along the subdivisions of the cerata. Liver in three divisions, ramifying to the cerata and to the rhinophore sheaths; labial disk armed with chitinous rodlets; masticatory margin of mandibles denticulate; radula triseriate, similar to that of *Galvina*, the median tooth denticulate, the laterals broad and smooth; genitalia unarmed.

#### HISTORY OF THE GENUS *HANCOCKIA*.

The genus *Hancockia* was described by Gosse in 1877, being based upon a single specimen, *Hancockia eudactylota* Gosse, dredged in about 6 fathoms off Torquay on the northern side of Tor Bay, Devonshire, England. Another specimen dredged in Plymouth Sound was recorded by Gamble (1892), three additional ones from the same region were studied by Eliot (1906), and three more were recorded by the same author in 1910, others in 1912. In 1885, Trinchese described as new the genus *Govia*, with two species from the Bay of Naples, adding in 1886, a more extended study of their anatomy based upon the four specimens taken. This genus is without doubt congeneric with the earlier described *Hancockia* of Gosse and the name *Govia* is hence a synonym, so recorded by Pruvot-Fol (1931), and by Odhner (1914).

*Govia viridis* Trinchese can be scarcely more than a color variety of *Govia rubra* Trinchese, and both are probably identical with *Hancockia uncinata*. Unfortu-

nately no further specimens have been taken at Naples so that additional information is lacking and much to be desired. Judging by the variability in color of the California species, it is very probable that a similar range may be found in the Mediterranean forms when sufficient material is at hand.

Garstang (1893) has shown that *Doto uncinata* Hesse (1872) is actually a form of *Hancockia* and probably identical with *Hancockia eudactylota* Gosse, with which opinion Eliot (1906, 1910, 1912), Pruvot-Fol (1931), and Odhner (1914, 1936), concur.

The genus appeared to be rare with but few specimens (nine) having been recorded up to 1923, in which year the present writer published the description of *Hancockia californica* together with anatomical and other details. While not common, this species has been found rather frequently, and it is to be expected that careful collecting may increase its range considerably.

Assuming that the Mediterranean species is distinct from the English ones, and that the two Neapolitan species are identical, the following represents the list of known species at present.

1. *Hancockia uncinata* (Hesse), 1872.

Syn. *H. eudactylota* Gosse, 1877.

Syn. *Govia rubra* Trinchese, 1886.

Syn. *Govia viridis* Trinchese, 1886.

France: Brest, Banyuls; England: Tor Bay, Plymouth;

Italy: Bay of Naples, Rovigno, Messina.

2. *Hancockia californica* MacFarland, 1923.

Monterey Bay.

3. *Hancockia papillata* (O'Donoghue, 1932).

Syn. *Iduliana papillata* O'Donoghue.

India: Gulf of Manar.

In 1932, O'Donoghue proposed the new genus *Iduliana*, with *Iduliana papillata*, new species, as the genotype for a new nudibranch taken at Krusadai, Gulf of Manar, India. I agree with the opinion of Odhner (1936, p. 1104) that *Iduliana* is identical with *Hancockia*, the species *H. papillata*, however, being a good one. The median dorsal hemispherical swelling is the cardiac elevation of *Hancockia* and the tubular ridges passing out from it are the equivalent of the vascular channels from the cerata to the auricle of the heart as described by me in *Hancockia californica* (1923, pp. 81-82 and pl. 1, fig. 1). The radula shows no generic differences, aside from O'Donoghue's inversion of the terms anterior and posterior as elsewhere in the same paper.

Detailed figures are much to be desired though the minute size of the single specimen evidently prevented satisfactory anatomical study, especially of the median dorsal papillae.

The dimensions of the preserved specimen "4 mm. long, 2 mm. high to the top of the elevation, 2.5 mm. to the top of the cerata, and 12.5 mm. wide, excluding the cerata" are undoubtedly incorrect since the width of 12.5 mm. with a length of 4 mm. can only be ascribed to a typographical error.

**Hancockia californica** MacFarland

Plate 38, figures 7-9; plate 43, figures 45-50; plate 49, figure 7;  
plate 50, figure 5; plate 52, figures 7, 7a; plate 53, figures 1-6

*Hancockia californica* MACFARLAND, 1923. Journ. Morphology, vol. 38, no. 1, pp. 65-104, pls. 1-6.

*Body* elongate, compressed, the highly arched dorsum set off from the foot by a well defined longitudinal groove. Tail short, rapidly tapering to a blunt, slightly notched tip.

*Head* rounded, bearing on either side a broad, palmate, velar lobe with six to ten or more finger-like subdivisions of unequal length, the longest reaching one-half the length of the whole lobe, the shortest mere tubercles.

Dorso-lateral margins with a single series of four to seven non-caducous *cerata* on each side. The first pair opposite, in front of the prominent cardiac elevation of the dorsum, the succeeding ones progressively less directly paired until the posterior ones are alternately placed, those of the right side being shifted backward in each case. Each *ceras* arises from a stout base and expands into a palmate distal portion, strongly concave on its outer face, and bearing on its margin a series of from 4 to 16 digitiform projections arranged in a horseshoe-shaped grouping, a median dorsal one above, the others along the anterior and posterior margins of the expanded *ceras*. The largest of these may bear irregular nodular tuberosities on their margins, those on the anterior *cerata* being larger, more numerous, and even forming short branches, while on the posterior ones the whole structure becomes smaller and less complex. (Pl. 38, figs. 7-9.) The numerous rounded elevations found on the finger-like subdivisions indicate the position of cnidosacs.

*Rhinophores* nearly erect, divergent, inclined slightly forward and outward, arising from the dorso-lateral margin of the head. The stalk is slender and bears a vertically perfoliate, bulb-like enlargement, or clavus, terminated above by a short blunt apex which is surrounded by a large funnel-shaped or calciform sheath into which the clavus is deeply retractile. The vertical leaves of the short clavus are few in number and merge gradually with the stalk below, but more abruptly above. The cylindrical, blunt tip above the clavus is one-fourth the length of the latter.

The thin margins of the sheaths bear six to nine slight, blunt elevations, irregularly spaced, the terminations of ridges along the outer surface of the sheath which approach and merge into each other and into the stalk of the rhinophore below. Each ridge bears a series of minute nodosities on its outer surface, each containing a cnidosac, while the surface between the ridges is web-like and smooth. (Pl. 38, fig. 8.) (MacFarland, 1923, pl. 1, fig. 3.)

*Foot* narrow, linear, bluntly rounded in front, with a narrow, median notch, the posterior end relatively broad and rounded, slightly notched in the median line and usually folded into a deep, longitudinal groove along its ventral surface, forming a grasping organ suitable for slender branches of algae.



Surface of *dorsum* highly arched, the prominent cardiac elevation forming an elliptical hillock between the first and second pairs of cerata. From the posterior end of this elevation a well defined ridge is usually formed by the posterior median vein passing to the heart. It has a somewhat zigzag course along the mid-dorsal area and receives tributary veins from the anterior and posterior bases of each ceras, thus forming a series of ridge-like elevations, very prominent in some specimens, and less conspicuous or even concealed in others. These divide the dorsum into irregularly rhombic areas as is shown in figure 7 of plate 38.

*Anal opening* at the summit of a very low cylindrical papilla, midway between the first and second cerata of the right side, and high up close below a line connecting their bases as well as to the right margin of the cardiac elevation. The minute *renal opening* is close above the anal papilla and is best seen in sections.

The male and female *reproductive openings* are relatively large and contiguous and are located immediately in front of and below the insertion of the first ceras on the right side.

*Mouth* a longitudinal slit with moderately thin lips. Mouth cuticle thin, the inner lip-disk thick, forming a labial armature of a circular band of closely set cuticular rodlets surrounding the opening from the mouth tube into the pharyngeal bulb. This labial armature is common among the Doridacea, but apparently present only in the Dironiidae and Bornellidae among the Aeolidacea where usually a slight thickening occurs. Height of longest rodlets 0.033 mm., their diameter 0.006 mm. (Pl. 53, figs. 1, 2.)

*Mandibles* elliptical, thin and delicate, thickened somewhat at the hinge region. The anterior margin of each masticatory process is modified into an irregular series of some 20-30 blunt denticulations, irregularly worn immediately below the hinge region, reaching full prominence in the middle portion and becoming obscure below. The inner face of the lower part of the margin shows traces of tessellation and the processes appear to be in more than a single series. (Pl. 43, figs. 45, 46.)

*Radula* long, moderately wide, tapering but slightly, triseriate, its formula 50-62 (1·1·1). Median tooth massive, widely arched, bearing a strong, median, pointed cusp flanked on either side by three to five, usually four, strong lateral denticles. (Pl. 43, fig. 47.)

Lateral tooth a thin, transparent, flattened plate which may be easily overlooked, its inner posterior angle prolonged obliquely upward as a broad lancet-shaped cusp but slightly elevated above the plane of the plates. Inner margin of cusp abruptly rising to the tip, the outer margin more sloping with a variable shoulder or even cusp-like prominence near its outer end as it joins the basal plate of the lateral tooth. Inner basal angle of each lateral bifid, bearing two rounded or bluntly angular projections. Typical median teeth range in width from 0.021 mm. to 0.052 mm., and from 0.024 mm. to 0.054 in length, from end of base to tip of median cusp; the lateral teeth vary from 0.030 mm.

to 0.036 mm. in height of inner cusp, and from 0.044 mm. to 0.090 mm. in total width.

General *body color* reddish brown, varying from light to dark, tending to a garnet red. Not infrequently specimens are found having green to green-brown markings. The integument appears a deep cream, the varying range of color due, probably, to the dense and numerous liver branches throughout, which are modified by food. The red specimens closely resemble in color the larger species of *Gigartina* upon which they are frequently found.

The foot in these specimens is a clear translucent red-brown. The velar lobes and the cardiac elevation are a clear uniform color which follows the vessels arising from it, forming a prominent network of clear ridges on the dorsum. The areas so formed are crowded by patches of red, red-brown, and an occasional one of lemon yellow formed of minute points.

Oval patches of pure white occur on the convex dorsal sides of the cerata, and scattered white on the rhinophore stalks and on the edges of the clavus plates. In some individuals the white is aggregated into a series of irregular, larger white to lemon spots along the dorso-lateral region from the head back to the third pair of cerata. The cnidosacs are conspicuous as elevated white points on the rhinophore sheaths and the finger-like processes of the cerata. (Pl. 38, fig. 7.)

Younger specimens are always paler in color and markings. The decided range of color might lead to the assumption that more than one species was involved, but repeated collections have brought intermediate forms to the aquaria where they paired readily. I am inclined to believe that the two species *H. rubra* and *H. viridis* Trinchese are but color variations of one species as also stated by Pruvot-Fol and Odhner.

*Dimensions.* Total length of large specimen 21 mm., diameter of body in cardiac region 3 mm., maximum height 4 mm., the average being smaller.

*Habitat.* Monterey Bay, California, and adjacent coastline southward, near extreme low-tide level in rocky tide pools and channels off exposed rocky headlands. Often taken at Chinatown Point on *Gigartina* growing in channels between the granite rocks most exposed to the dash of the surf. Occasionally found floating foot uppermost at the surface in quiet tide pools at very low tide when the water is exceptionally smooth.

The egg band of *Hancockia californica* is a narrow ribbon of a pale green color, coiled in two or three turns and fastened to the fronds of brown algae. Copulating individuals have been taken in tide pools during July and August and even as late as in October, and the egg bands have been found during the same period. Pairing and egg-laying may also occur in the aquaria, usually but a short time after capture.

#### EXTENDED ANATOMICAL DESCRIPTION.

*Alimentary system. Simple oral tube glands.* (Pl. 53, fig. 1.) The mouth is surrounded by moderately fleshy lips inclosing a vertical slit which leads into the oral tube. It is lined with low columnar epithelium through which open many closely packed

simple tubulo-alveolar glands, the secretion of which is apparently mucus-like. These glands surround the short oral tube throughout its whole length but are less abundant on the ventral surface than on the dorsal and lateral ones. Since these are so distributed they may be scarcely designated anterior oral tube glands, but the term simple oral-tube glands may be used by virtue of their morphological type, the dilated spherical proximal end being made up of a few secreting cells from which the tube is prolonged as a slender duct threading its way through the muscular layers of the mouth tube to penetrate between the epithelial cells to the free surface where it opens.

*Posterior oral tube glands*, compound glands. Immediately in front of the lower margin of the labial armature in the median line is the opening of a common duct formed by the union of three tubes, one from either side, and the third a median one from behind. The lateral ducts are from the anterior salivary glands, the so-called glandulae ptyalinae of Bergh. The term posterior oral tube glands or pre-bulbar glands is preferable since it indicates anatomical relations only, the nature of their physiological secretion being unknown. (Pl. 53, figs. 1, 3.)

These large glands extend dorsally around the anterior portion of the pharyngeal bulb and are prolonged into the rhinophores nearly to their tips. The single, wide, muscular, ciliated duct is beset on all sides with closely crowded pyriform or spherical acini, either sessile or with short ductules, and extends the full length of the gland.

The secreting cells in the acini are closely packed together with but a small lumen visible. Their nuclei are large, deeply staining, and the cytoplasm is usually filled with fine basophile granules, while in adjacent cells it may be entirely clear and vacuolar with small parietal nuclei.

Similar glands are described by Trinchese (1886) for *H. viridis* and *H. rubra* which penetrate the bases of the rhinophores, the duct being ramified, instead of undivided as here.

The median unpaired duct of the three is lined with clear ciliated cells of a low columnar or cuboidal form, surrounded by a thin layer of muscle and connective tissue. This duct leads into a *long unpaired gland* extending back below the lobes of the ovotestis to the region of the third or fourth ceras of the right side, over three-fourths the total body length. (Pl. 53, fig. 3, *m.s.*)

*Paired posterior salivary glands*. These branched tubular glands lie immediately behind the pharyngeal bulb and send their paired ducts through the nerve collar to penetrate the musculature of the pharyngeal bulb on either side, opening into this cavity laterally opposite the anterior angle of the radula. (Pl. 53, figs. 1, 4.)

The lumen of the pharyngeal bulb bears a cuticular lining throughout of varying thickness, laterally being modified into the mandibles, as previously described, in the median area covering the prominent odontophore and modified into the radula. The cuticle of the superior median face of the radula sac is modified into a high longitudinal ridge, seen at *c. r.* in figure 1 of plate 53 and in cross sections in figures 16, 17 of plate 5, 1923. This is more fully described by MacFarland (1923, p. 76) and represents a differentiation as yet not described in any aeolids.

The oesophagus is a curved tube, passing downward and backward, being displaced to the left by the large anterior genital complex. It is lined by relatively tall columnar epithelium characterized by small basally placed nuclei, clear finely granular cytoplasm, and bearing short fine cilia on the free surface. (Pl. 53, figs. 1, 3, *d*.)

A short distance before the oesophagus dilates into the anterior stomach, it gives off dorsally a blind, sausage-shaped diverticulum, the distal end of which is directed forward. This pouch (MacFarland, 1923, fig. 4, *d*) may reach a length of 0.67 mm., and a total diameter of 0.30 mm., the oesophagus, itself, immediately in front of its origin, measuring but 0.15 mm. in diameter. The epithelium of the diverticulum is made up of a single layer of closely packed, slender, cylindrical cells of much the same appearance as those of the oesophagus, but nearly three times as high. The remainder of the wall of both oesophagus and diverticulum consists of a few circular and longitudinal muscle fibers and of connective tissue. (MacFarland, 1923, p. 78.)

Behind this blind sac, the oesophagus, a structure recorded in but few aeolids, dilates into the stomach where two divisions may be distinguished, an anterior ventral one, thin-walled and roomy, and a posterior thick-walled muscular portion. The stomach curves upward and forward upon itself, the uppermost limb of the loop forming the thick-walled muscular segment while the lower forms the anterior thin-walled division. Upon the posterior curvature of this are given off close together an anterior hepatic duct, which divides at once into a right and a left main branch, and a posterior branch. From these, branches are sent out to ramify in the cerata, and in the case of the anterior trunks to the rhinophore sheaths as well. Many of the diffusely branched liver subdivisions terminate close below the outer epithelium of the cerata or rhinophore sheaths in small spherical cnidosacs connected with the exterior by a minute pore and packed full of very small, rod-shaped, slightly curved nematocysts. The presence of these cnidosacs is usually indicated externally by a slight elevation, being arranged on the rhinophore sheaths in elevated rows. (Pl. 53, fig. 3.) In no instance have I been able to observe the discharge of the nematocysts from the cnidosacs in the living animal.

The posterior hepatic duct courses backward to the end of the pseudocoelom below the lobules of the ovotestis instead of the usual position above the lobules, a position shared by *Glaucus*, *Pteraeolidia*, *Cuthonella*, the Janidae, Dendronotidae, and Hermaeidae.

In the second, muscular division of the stomach, immediately behind the entrance of the hepatic ducts, the increased muscle fibers are predominately circular and the epithelium is raised into a narrow zone of longitudinal rows of low, bluntly conical or compressed papillae, each of which is crowned by a thickened cap of cuticle forming a gastric mill similar in relationships to that described for the Duvaeuliidae in the present paper. This, however, is made up of rows of papillae elongated into short ridge-like elevations crowned by the thick cuticle (MacFarland, 1923, pl. 2, fig. 7). The total length of the zone occupied by the armature reaches 0.4 to 0.5 mm. in a specimen of 15 mm. total body length.

*Circulatory system.* A high hemispherical cardiac elevation on the dorsal surface between the second and the third pairs of cerata incloses the heart. Beneath this elevation a zigzag ridge may be traced from the heart back to the posterior end of the animal, alternately directed to the right and left toward points midway between successive cerata of each side. At each lateral angle thus formed, it receives similar though smaller elevations from each of the two adjacent cerata, thus marking off a series of rhombic areas upon the dorsum (pl. 38, fig. 7). These elevations correspond to the main venous channels beneath the integument, bringing blood from the cerata to the auricle. From the first pair of cerata in front of the heart, a right and left vein, similarly located, open into the anterior ends of the auricle. Into these dorsal venous channels the blood lacunae of the body wall open freely so that they collect the blood which has been aerated in the cerata and the general body integument, and conduct it on to the heart.

*Kidney.* The kidney in *Hancockia* is a broad, roomy sac extending nearly the full length of the body along the dorsal surface of the viscera immediately below the integument, the heart, and its main veins. Laterally it is prolonged into numerous blunt, slightly branched diverticula, which extend for a short distance down the sides. Below the heart the renal sac is prolonged forward on the left side around the aorta, in front remaining independent of the other rami of the organ, thus lying on the left side of the aorta.

To the right, and behind the passage of the latter vessel through the pericardial wall, the reno-pericardial syrx forms the connection between the pericardium and the kidney. It is a bluntly elliptical, or barrel-shaped organ, slightly flattened dorsally, and about two and one-half times as long as broad. Its muscular wall is lined with high columnar cells bearing long cilia. The lumen of the syrx is smooth and uniform, save for a slightly developed ridge on the mid-dorsal and mid-ventral surfaces, rather than the conspicuous folds usually found. Close to the opening of the syrx into the renal sac, a short canal is given off which passes directly upward and to the right, and opens externally by the nephroproct directly above and close to the anal opening. (Pl. 53, fig. 3, a.)

*Central nervous system.* The cerebral commissure is extremely short. The ovoid pedal ganglia are united to the cerebro-pleural ones of each side by short cerebro-pedal and pleuro-pedal connectives, visible readily in lateral and ventral views. (Pl. 53, fig. 4.) The pedal commissure is extremely short, visible after carefully pressing the ganglia apart.

The slender parapedal commissure is long as seen in my figure 14, plate 4, 1923. The suboesophageal-cerebral commissure (fig. 14, s.c.c.) arises from the ventral face of either cerebral ganglia and loops around the oesophagus in front of the short pedal commissure.

The spherical buccal ganglia (pl. 53, fig. 4), united by a short and relatively strong commissure, lie in contact with the inner anterior face of the pedal ganglia im-



mediately below the oesophagus. To each buccal ganglion is attached a small gastro-oesophageal ganglion.

From the postero-lateral face of each pleural ganglion the pleuro-visceral commissure arises (pl. 53, fig. 4, *pl. com.*), forming a loop around the oesophagus close to the pedal ganglia. From its right half is given off the genital nerve.

The rhinophore ganglia are large and situated at the base of the clavus of each rhinophore to which they send many fine nerves. The rhinophore nerve (pl. 53, fig. 4, *c.1*) is the largest nerve from the anterior surface of the cerebral ganglia.

A distinct though small oval optic ganglion is borne at the origin of the short optic nerve at the outer posterior border of the cerebral ganglia, above the space between the roots of the cerebro-pedal and pleuro-pedal connectives. From the optic ganglion a fine nerve passes forward to the eye situated close beside the cerebral ganglia and slightly below their mid-level. The eyes are deeply pigmented with black and each contains a conspicuous clear lens.

Behind the pleuro-pedal connective is the conspicuous large statocyst (pl. 53, fig. 4, *s.*), its nerve, the sixth cerebral, only visible in sections. This contains a single spheroidal statolith 0.022 mm. by 0.0275 mm. in diameter, twice the dimensions given by Trinchese (1886) for that of *Hancockia rubra*.

*Reproductive system.* (Pl. 50, fig. 5.) The *ovotestis* is made up of a very large number of spheroidal lobules, each composed of a pear-shaped portion and small closely packed peripheral lobules. These latter produce the ova, the central part the spermatozoa. The thin-walled duct arising from the median apex of the central cavity soon unites with the main hermaphroditic duct, coursing forward slightly below the median axis of the body.

At the median dorsal surface of the anterior genital complex (pl. 50, fig. 5, *h.d.*), it dilates into the sausage-shaped hermaphroditic ampulla (*h. amp.*). From the distal posterior end of the ampulla the narrowed duct again passes forward, gives off a branch to the left, the oviduct (*ov. d.*), and dilates at once into the thick-walled prostatic segment (*pr.*) of the vas deferens, lying in a number of loops upon the anterior face of the complex. It passes into the basal inner end of the roomy preputial sac which opens externally as the male orifice in front of the first ceras on the right side of the body.

The duct passes into the large somewhat flattened and plicated glans (*gl.*) which opens midway of its ventro-anterior face, not at the apex as expected. The short oviduct (*ov. d.*) opens into the small, spherical spermatheca (*sph.*), the distal duct of which passes at once downward into the thin-walled fertilization chamber, close to the opening of the albumen gland into the latter. Into this flattened ciliated cavity also opens the mucous gland (*m.g.*) which makes up the bulk of the anterior genital complex.

From it the *vaginal* or *copulatory* duct leads into the female atrium which opens to the exterior close behind the male opening. The vaginal duct is crescentic in cross section and strongly ciliated.

The upper horn of the crescent forms a groove leading directly into the duct from the spermatheca by way of the dorsal portion of the ciliated chamber, and evi-



dently serves as the channel for the spermatozoa from the female atrium during copulation.

The ventral horn of the crescent opens widely into the lumen of the mucous gland and forms the path of the eggs during oviposition.

The diagram (pl. 52, fig. 7) expresses these relations in a simplified manner. The sequence of events in the reproductive cycle is probably as follows: as the spermatozoa mature they pass from the central spermiatic chamber of each lobe of the ootestis through the hermaphroditic duct (*h.d.*), to the hermaphroditic ampulla (*h.a.*) where they are accumulated and reach maturity.

During copulation, which is reciprocal, the spermatozoa pass onward from the ampulla through the prostatic segment of the vas deferens (*pr.*) and are deposited close to or within the vaginal canal (*v.*), through the upper groove of which (pl. 52, fig. 7a at *c*) they pass to the spermatheca.

Shortly after copulation, the ova pass through the hermaphroditic duct, the ampulla, and the oviduct, past the opening of the spermatheca, and come in contact with the spermatozoa, either here or in the fertilization chamber (*f.*). In the cavities of the accessory glands, the ova receive a coating of albumen from the albumen gland (*alb.*), then one of mucus from the lobes (*m.*) of the left side, and finally are united into the continuous egg band by the secretions of the larger nidamental gland on the right, and pass outward through the ventral groove of the vaginal canal (*ov.*) and through the vestibulum as a narrow ribbon and are fastened in a coil of two or three turns of a pale greenish color upon the fronds of *Laminaria*, *Delesseria*, or other similar brown algae. The eggs are found in bands in the pools during the latter half of the year.

Systematic relationships and structural characteristics peculiar to *Hancockia*:

1. Presence of labial armature of rodlets.
2. Presence of median unpaired salivary gland opening into the united ducts of the paired posterior oral tube glands, and extension of paired posterior oral tube glands into rhinophores.
3. Development of a median longitudinal cuticular cutting ridge on dorsal surface of the external odontophore epithelium.
4. Oesophageal diverticulum in front of the stomach.
5. Development of circular gastric armature in posterior end of stomach.
6. Ramification of hepatic tubules into the rhinophores as well as the cerata, and presence of cnidosacs in both.
7. Ventral position of posterior hepatic duct below the lobules of the *ovotestis*.
8. The greatly shortened cerebral and pedal commissures.
9. Digitate character of the velar processes and the cerata.

The author in 1923 (Morphology of *Hancockia*. Journal of Morphology, vol. 38, no. 1, p. 89) stated that the systematic position of the genus was obscure; Bergh and Eliot had assigned it to Dotonidae and Lomanotidae respectively; however, the affinities with these families seemed vague. I felt justified in establishing a separate family

in the group of the Dendronotacea, and this paper so places the genus *Hancockia* in the family Hancockiidae.

## Family DENDRONOTIDAE

### Genus *Dendronotus* ALDER AND HANCOCK

*Dendronotus* ALDER and HANCOCK, 1845. Athenaeum, no. 922, p. 644. Type *Tritonia arborescens* Müller, 1776 = *Amphitrite frondosa* Ascanius, 1774. ALDER and HANCOCK, 1846. Monogr. British Nudibranchiate Mollusca, part 2, fam. 3, pl. 2.

*Amphitrite* ASCANIUS, 1774. Trondhj. Vidensk. Selskabs Skrifter, vol. 5, p. 155, pl. 5, fig. 2. (Not O. F. Müller, 1771.) Type *Amphitrite frondosa* Ascanius.

*Amphitritidea* KRØYER, 1846. Amtliche Berichte 24 Vers. Deutscher Naturforscher u. Aerzte, Kiel, pp. 114, 217. [1847.] *Nomen nudum*.

*Amphitritidia* KRØYER. (fide Paetel, 1875, p. 9). KRØYER, 1846. Sched. Mus. Reg. Dan., p. 217. *Nomen nudum*.

This widely distributed genus of north circumpolar areas was established by Alder and Hancock in 1845 to receive the species *Doris arborescens* O. F. Müller, 1776. As *Tritonia arborescens*, and later as *Dendronotus arborescens*, this species gained wide recognition in the zoological literature, but has been shown since to be identical with the earlier *Amphitrite frondosa* of Ascanius, 1774. The generic name *Amphitrite* being already preoccupied by O. F. Müller, 1771 (*Vermes*), the genotype is fixed as *Dendronotus frondosus* (Ascanius, 1774). It is of wide distribution in Arctic seas and northern Atlantic and Pacific waters, being recorded from Nova Zembla, Greenland, Iceland, Norway, Faroes, Shetland Islands, the west coasts of Europe to the Bay of Biscay; the east coast of North America, Bay of Fundy (Verrill) to Cape Cod; and is represented in the North Pacific, Bering Sea, and Alaska by the same or allied species as far south as southern California, and as *D. elegans* Verrill on the Asiatic coast.

From the North Pacific and adjacent waters the following species have been recorded:

1. *Dendronotus frondosus* (Ascanius, 1774)

Bering Sea; Bristol Bay; S. W. of Hagemeister Island

Albatross Stations 3283, 3393, 3305, dredged

Plover Bay, Siberia, and St. Lawrence Island, Alaska (Krause, 1885)

Vancouver Island region, 15 - 20 fms. (O'Donoghue, 1921).

2. *Dendronotus iris* Cooper, 1863

Santa Barbara, California, washed up on beach at low tide, also in 20 fms. (Cooper).

3. *Dendronotus purpureus* Bergh, 1879

Bering Sea, Port Moller, Alaska Peninsula, 17 fms. (Dall).

Japan Sea, south of Vladivostok, 42°16'N. Lat., 130°44'E. Long., 90-300 fms. (Schönaue).

Differs from *D. frondosus* in color and especially in the very weak denticulation of the cusp of the median tooth. Probably a variety rather than a distinct species. It is held by Odhner to be a variety of *Dendronotus frondosus*. No other records from the northwestern Pacific have as yet been made.

4. *Dendronotus dalli* Bergh, 1879

Bering Strait, 35 fms. (Stimpson); Nova Zembla (Vayssi re); North Pacific Ocean, Blake Expedition; Bering Sea, Unalaska (Dall); Vancouver Island region 10 - 40 fms. (O'Donoghue).

Closely allied to *D. frondosus* but probably distinct according to O'Donoghue. According to Bergh, the cusp of the median tooth is entirely smooth; O'Donoghue states, however, that his specimens show "a short row of minute denticles not nearly so extensive or well marked as those present in *D. arborescens*," and his figure 54 of plate 11 (pl. 5 in explanation of plates) shows them as scarcely visible in the outline drawing. Vayssi re describes and figures strong but inconspicuous denticles on the median tooth.

According to Odhner (1936), *Dendronotus dalli* is at most a variety of the circumpolar species *Dendronotus frondosus*, which is very probable.

5. *Dendronotus giganteus* O'Donoghue, 1921

Vancouver Island region, 10 - 25 fms. (O'Donoghue); Puget Sound (Agersborg); off central California coast from Point Reyes region southward to Monterey Bay and beyond, about 15 fms. (MacFarland).

This is most probably to be considered as identical with *Dendronotus iris* Cooper, the color descriptions being remarkably close.

6. *Dendronotus rufus* O'Donoghue, 1921

Vancouver Island region, 12 - 20 fms. (O'Donoghue).

Considered by Odhner to be a variety of *D. frondosus*.

In accordance with the views of Odhner, this list must be rearranged under two species as follows:

1. *Dendronotus frondosus* (Ascanius, 1774)

var. *purpureus* Bergh, 1879

var. *dalli* Bergh, 1879

var. *rufus* O'Donoghue, 1921

2. *Dendronotus iris* Cooper, 1863

syn. *Dendronotus giganteus* O'Donoghue

In the present paper this species is recorded from the San Francisco and Monterey Bay regions, intermediate between the two.

Three additional species are described in the following pages, all from the Monterey Bay region, and clearly distinct from the above forms. These are:

*Dendronotus subramosus*, new species

*Dendronotus venustus*, new species

*Dendronotus albus*, new species

A more detailed examination of *Dendronotus iris* Cooper, than has yet been published, is also given.

*Dendronotus frondosus* (Ascanius)

*Amphitrite frondosus* ASCANIUS. 1774. K. Norske Selskabs Skrifter 5, p. 155, pl. 5, fig. 2.

*Doris arborescens* MÜLLER. 1776. Zool. Danicae Prodrömus, p. 229.

*Dendronotus arborescens* MÜLLER, ALDER and HANCOCK, 1845. Athenaeum no. 922, p. 944. ALDER and HANCOCK. 1846. Monogr. Brit. Nudibr. Moll., fam. 3, pl. 3, 1845, fam. 3, pl. 2, 1846. BERGH. 1884. Bull. Mus. Comp. Zool. Harvard, vol. 25, no. 10, pp. 137-139. BERGH, 1885 [1888]. Nudibr. "Willem Barents," Bijdr. Dierkunde, Afl. 14, A. g. 4, pp. 25-35, pl. 2, figs. 12-28.

*Dendronotus purpureus* BERGH. 1879. Proc. Acad. Nat. Sci. Philadelphia, vol. 31, pp. 89-94, pl. 1, figs. 18-20; pl. 3, figs. 7-12. BERGH. 1900. Zool. Jahrb., Syst. Abt. 13, pt. 3, pp. 241-242, pl. 21, figs. 74-77.

*Dendronotus dalli* BERGH, 1879. Proc. Acad. Nat. Sci. Philadelphia, vol. 31, p. 94, pl. 1, fig. 21; pl. 2, figs. 9-12; pl. 3, figs. 2-6. BERGH. 1894. Bull. Mus. Comp. Zool. Harvard, vol. 25, no. 10, pp. 139-141, figs. 2-5. BERGH. 1904. Zool. Jahrb., Syst. Abt. 13, pt. 3, pp. 241-242, pl. 21, figs. 74-77. BERGH. 1904. Malacol. Unters. 9, 6, 1, figs. 18-19. O'DONOGHUE. 1921. Trans. Roy. Can. Inst. Toronto, vol. 13, pt. 1, pp. 186-187, pl. 5, fig. 46; pl. 6, figs. 55-56.

*Dendronotus rufus* O'DONOGHUE. 1921. Trans. Roy. Can. Inst. Toronto, vol. 13, pt. 1, pp. 190-192, pl. 3, fig. 25; pl. 4, fig. 48. Listed as *D. "nuber"* an error for "*rufus*." O'DONOGHUE, 1922, *ibid*, vol. 14, p. 124. ODHNER. 1936. Nudibr. Dendronotacea. Mém. Musée Royal d'Histoire Naturelle de Belgique, ser. 2, fasc. 3, pp. 1063-1109, text figs. 3, 4, 39 a.

*Diagnosis.* Body linear, rather higher than broad, laterally compressed, pointed behind, the dorsum somewhat rounded. Dorso-lateral margins with three to seven pairs of processes, strongly branched in large individuals less so in smaller ones.

Rhinophore sheaths without posterior crest; with usually four or five arborescent processes on the margins, with an external lateral arborescent process midway of the stalk.

Velum narrow, rounded, bearing five to ten large branching processes with intermediate smaller ones between them. A few simple processes between these and the dorsal lips. Radula formula 24-49 (9-15:1-9-15). Median tooth wide, with multi-denticulate triangular cusp. Laterals long, tips curved, outer margin denticulate.

Masticatory process margin with a single series of small denticles.

Prostate discoid with several concentric series of vesicles.

Vesicula seminalis (spermatheca) present.

Color uniformly pale, orange or reddish brown, or marbled with these colors and with small, opaque, yellow, red, and white spots.

Size usually of moderate dimensions up to 100 mm. in length.

Distribution in Pacific waters and in general as previously given.

*Dendronotus purpureus* Bergh, 1879.

This species was described from a single specimen taken off Port Moller, Bering Sea, in 17 fms. by Dall in 1874. It was later questioned by Bergh, 1894, p. 139, and 1904, pp. 15-18, after a study of three specimens dredged between Vladivostok and Nagasaki in the Sea of Japan as possibly being merely a darker variety of *D. arborescens*. The wide range of color in the latter species probably deprives it of even varietal status.

*Dendronotus dalli* Bergh, 1879.

Described originally from a large pharyngeal bulb dredged in 35 fms. in Bering Strait, and later (1894, p. 139) supplemented by the study of two specimens of the whole animal taken by W. P. Blake in the North Pacific, and (1904, p. 18) of a specimen taken by Dall in Unalaska, as a result of which he questions the validity of this species, suggesting that it may be a variety in which the denticulation of the cusp of the median tooth is wanting. O'Donoghue (1921, p. 187), however, holds to the specific validity of *D. dalli* as distinct from *D. arborescens* as shown by the external characteristics of preserved specimens. He gives no anatomical details to support his conclusion, and until these are produced, the conclusions of Odhner (1936) that the radula characteristics are too variable to justify species discrimination are most reasonable.

*Dendronotus rufus* O'Donoghue, 1921.

This was described from specimens taken in the Vancouver region, British Columbia.

The animal ranged in color from a translucent gray to a deep brick-red. The radula formula is given as 32-35 (6-8·1-6-8) and lies well within the range of variation recorded for *D. frondosus*, as do the color and other external characters noted by O'Donoghue. Unless detailed anatomical studies may show specific characters, the conclusion of Odhner (1936, p. 1108) that the two species are identical is without doubt correct.

*Dendronotus iris* Cooper

Plate 47, figures 12-18; plate 48, figures 1-6; plate 49, figure 4;  
plate 50, figure 1; plate 51, figures 1-5

*Dendronotus iris* COOPER, 1863. Proc. Calif. Acad. Nat. Sci., vol. 3, p. 59. ODHNER, 1936. Nudi-branchia Dendronotacea. A Revision of the System. Mém. Musée Royal d'Histoire Naturelle Belgique, ser. 2, fasc. 3, pp. 1107-1109, pl. 1, fig. 9, text fig. 40.

*Dendronotus giganteus* O'DONOGHUE, 1921. Trans. Roy. Can. Inst., Toronto, vol. 13, pt. 1, pp. 187-190, pl. 4 (10), fig. 47; pl. 5 (11), figs. 57-59.

This species was described by Cooper in 1863, and was based upon several specimens which had been washed up on the beach at Santa Barbara, California, at low tide. His original description is not readily obtainable but reads as follows:

"Pale purple, varying to orange red, foot narrowly edged with white, tentacles with white tips and a subterminal orange ring, branchial processes purple, the smaller ones sometimes olive near the base. Length of largest specimens 3, breadth 0.50 inch.

"Several found on the beach at Santa Barbara, May 5th, having been washed ashore by an unusually heavy sea, occurring at a very low stage of the tide. One, also, dredged on seaweed, from a depth of 28 fathoms, two miles off the shore.

"This species seems more variable in color than the other *nudibranchiata* of this coast, but I saw no reason for considering them of more than one species. Those washed ashore being somewhat injured, although still alive, I made no drawing of them, and the more perfect one dredged was too small for this purpose.

"In the 'Mollusca and Shells,' of the U. S. Exploring Expedition under Commodore Wilkes, Dr. Gould mentions a species of *Dendronotus* collected at Puget Sound, but does not name it or give any clue to its characters, except that the *branchiae* have white tips, unlike our specimens. It is very probable, however, that it belongs to the same species, as so many of the Mollusca of this coast have an equally wide range."

The same species was described as *D. giganteus* by O'Donoghue in 1921 from specimens dredged at depths of from 10 to 25 fathoms at various points in the Vancouver Island region, where it is not at all rare. It has also been taken by Agersborg from Puget Sound near Friday Harbor, Washington. I have had numerous specimens of this form taken from the California coast, the first, through the kindness of Professor C. H. Gilbert, taken in a trawl net by fishermen off Point Reyes, others, later, from the same region, and from dredgings in San Francisco Bay and Monterey Bay at various times and in moderate depths. It does not appear to be as abundant in the last-named locality as farther northward.

*Body* limaciform, somewhat compressed; foot rounded in front, the lateral margin not prominent, tail short.

*Frontal veil* obscure, marked by six to eight large, branched processes, the innermost two the largest. Below this row and the mouth three more irregular transverse rows of simple digitate or branched processes.

*Detailed description.* The general *body shape* is limaciform, the rounded dorsum passing downward into the vertical sides without any visible demarcation, except for the series of dorso-lateral appendages. The foot margin projects but slightly beyond the plane of the sides of the body. It is rounded in front, with a slight indication of a median notch in some specimens, and terminates behind in a short bluntly pointed tail. The head bears a slightly marked frontal veil, with four indistinct transverse rows of processes. The series nearest the mouth are quite short and conical in shape, and vary from 10 to 20 in number. Outside of these a second row is made up of some six to ten longer slender processes, usually simple, but occasionally with short pointed branches. The third series has six to eight stouter and simply branched processes of irregular length, but usually twice as long as those of the second row. The outermost row con-



tains six or eight large, stout, well branched processes, arranged in fairly symmetrical grouping on either side of the median line and marking the actual velar margin, the others being between it and the mouth. The general appearance and branching of the largest processes resembles that of the dorsal papillae. Figure 4 of plate 49 is a composite drawing from several of the best preserved specimens, representing a ventral view of the velar region, and gives an idea of its complexity, which is greater than that described for any other species. The distinction pointed out by Odhner as regards the comparative length holds good in many specimens but, owing to contracting in varying degree, is not as apparent as it would be in life.

*Dorso-lateral papillae* stout, dendriform, arranged in five or six pairs.

*Rhinophores* large, the clavus perfoliate, retractile within sheaths bearing five or six wide-spreading arborescent processes, the largest ones behind, smaller and much less branched ones in front. The posterior face of the rhinophore stalk bears a vertical series of three or four smaller slightly branched processes similar to the marginal ones, but much less extensive, the outer base of the stalk with a long, stout, arborescent process.

*Anus* in right dorso-lateral line nearly midway between first and second processes, the renal pore close above it.

*Inner labial ring* of cuticular rodlets.

*Mandibles* large, deep reddish brown, the dorsal process strong, the ventral masticatory process strong with the margin denticulate. (Pl. 47, figs. 12-18.)

*Radula* broad, teeth in 36-46 transverse rows, median tooth strong, the cusp triangular, its sides concave, bearing 12-16 very strong denticles. Lateral teeth 11-20 with a low pointed hook, usually smooth but occasionally with finely serrated edge or with one to four small pointed denticles on the innermost laterals of the most anterior (oldest) rows. (Pl. 48, figs. 1-5.)

*Reproductive openings* below first dorsal process on right side. Penis cylindrical, bluntly tapering, unarmed; prostate made up of closely set vesicles along the greater part of the length of the vas deferens. A small bursa copulatrix is borne upon the distal end of the vaginal canal, a large vesicula seminalis (spermatheca) forming a dilatation of the proximal end of the vagina.

The *rhinophores* (pl. 48, fig. 6) consist of stout stalks, inclined slightly forward, terminating above in a sheath for the retractile clavus. The sheath margin is prolonged into five or six widely spreading arborescent processes. The two most posterior of these processes are the longest and most extensively branched, the inner one is next so, while the anterior two or three are shorter and much less branched. O'Donoghue gives four as the number of these processes, but I find five or six as the more common number in my material. Arranged in a vertical row down the posterior face of the rhinophore stalk are borne a series of three or four slightly branched, smaller processes, resembling those

borne upon the margin of the sheath above. These are apparently of constant occurrence, and form a ready means of identifying the species, since they are not recorded in any other yet described, so far as I am aware. O'Donoghue (1921) evidently refers to these in stating that the posterior edge of the rhinophore sheath bears a series of from three to five small but well-marked dendriform papillae, the location given being probably an error, the rhinophore stalk being intended.

The conical clavus is perfoliate, with from 16 to 30 leaves, which alternate in breadth as a rule. It is completely retractile within the sheath, a thin, smooth, narrow rim marking the edge of the opening. Upon the outer side of the stalk, close to its base, is borne a very stout and long, well branched, tapering process, directed outward, its length usually exceeding that of the rhinophore.

The *cerata* are five or six in number on either side, arranged in pairs along the dorso-lateral margins of the back. Their trunks are stout and much branched, the first two pairs breaking up almost at once into three main divisions from which the finer ramifications are given off; the more posterior ones are successively simpler, the hinder ones consisting of but a single branching trunk. As given by O'Donoghue, the first pair is located about one-third of the total body length from the anterior end, the second pair about midway. As would be expected from its size, *D. iris* probably exhibits the most extensive branchings of its *cerata* and other processes of any species of the genus.

The *anal aperture* is in the dorso-lateral line about midway between the bases of the first and second papillae on the right side, the small renal pore being close above the anal elevation.

The *reproductive openings* are upon the right side, almost directly below the first dorsal papilla. The female openings are at the ends of a slightly crescentic groove, the lower one covered in part by a thin flap of the integument from in front. The penial opening, with its frequently everted penis, is immediately in front of the two.

*Ground color* yellowish brown, darker above, terminal subdivisions of the main branches of the dorsal and velar papillae varying from orange to light lemon yellow. Foot edged with a narrow line of white.

*Dimensions* of alcoholic specimens range from 45 mm. to 100 mm. in length. One contracted specimen was as follows: 87.3 mm. long, 22 mm. maximum height opposite first *cerata*; glans everted 15.3 mm. long, 4.8 mm. maximum diameter; highest *ceras* 27.3 mm. Specimens were probably one-fourth larger in life, but none attained the length 210 mm. recorded by O'Donoghue.

*Habitat.* From Santa Barbara to Vancouver region.

#### EXTENDED ANATOMICAL DESCRIPTION.

*Mouth armature.* The mouth opening is oval-shaped and is surrounded by fleshy, glandular, external lips. Within these, the inner muscular lips form the anterior

end of the pharyngeal bulb, and are frequently everted with it in preserved specimens. Their outer margins are strongly curved, the lateral faces convex, and the inner concave (pl. 51, fig. 1). In the section shown in plate 51, figure 2, *a*, *b*, *c*, the relations of the outer lip margin, the inner lip, and the anterior masticatory edge of the mandible are seen. The outer glandular lip is drawn in part only, its outer surface not being included in the section. The inner lip is strongly muscular and in the figure cited presents a slightly convex inner surface which, however, is due solely to the local contraction of the muscles of the external margin. Plate 51, figure 3, illustrates the more usual appearance, in this instance representing a front view of the inner lip region as seen in an everted condition. The inner concave face is covered with a strong cuticle which thickens progressively backward and forms a prehensile ring or collar (*b*), surrounding the inner opening of the mouth, just in front of the masticatory processes of the mandibles (*c*). Here the cuticle tends to fray out into an irregular fringe of rodlets, each one corresponding to the epithelial cell at its base which secreted it. This collar is seen in perspective view from the front (pl. 51, fig. 1), and in horizontal sectional view (pl. 51, fig. 3). As is here shown, the main thickness of the cuticle is intact over the epithelial surface, save at the outer margin of the inner opening, the outer portion at the angle alone breaking up into its constituent rodlets. The epithelial surface is smooth in front of this frayed marginal area, but immediately behind it is thrown into a narrow zone of radial folds which are very conspicuous when the lip disk is examined from its inner face. These folds are covered smoothly by the cuticle as seen in the transverse section (pl. 51, fig. 4) and in perspective reconstruction shown in figure 5 of the same plate. The axes of the elongated columnar cells are in the main directed obliquely outward toward the free surface of the cuticle and the mouth opening, not, as would be expected, perpendicularly to the fold itself. The formation of these folds and the direction of the epithelial cells insures a much greater number of cuticular rodlets being packed together in this immediate border area of the prehensile collar than would be the case otherwise. The same organ shows interesting and specifically characteristic modifications in the other species to be described further on. O'Donoghue (1921) has evidently overlooked this important structure in his study, since he makes no mention of it.

*Mandibles.* The mandibles are a rich, deep reddish brown in color. In a preserved specimen of 91 mm. total length, the mandibles measured 17.2 mm. long by 7.5 mm. maximum width. The main portion of the mandible (pl. 47, fig. 12) is elongate mytiloid in form, its posterior border strongly convex. It is widest at the beginning of the posterior third, and is strongly convex throughout. The action of caustic potash or soda solutions upon the shape of the mandibles must be carefully controlled to avoid erroneous interpretations, for these structures are frequently warped out of their normal shape, especially when heated or boiled to remove the attached muscles. This seems to be especially true of this species, so that only preparations made by dissection were found to be trustworthy. The crista connective, forming the attachment of the hinge ligament, is relatively not so strongly developed in this species, as noted by O'Donoghue (1921). The dorsal process is strongly developed, its proportionate length in comparison

to that of the whole mandible being as 1 to 2.8 or 3. It is inclined obliquely backward at an angle of about  $40^\circ$  to the longitudinal axis of the mandible, and is connected to it behind the hinge region by a strong convex expansion through over one-half the length of the process. A narrow lamina at right angles to its surface is borne lengthwise of the dorsal process, extending the full length of its inner face from the hinge region to the tip, thus forming with it an upper and a lower lengthwise groove. The upper groove forms the insertion of the strong, superior, transverse muscle bridging across the interval between the dorsal processes, while the lower groove is seen merging with the ventral surface of the process.

The strong masticatory process is deep brown in color, is broadly united to the ventral border of the mandible by a thick arched expansion, its lower posterior end extending but a short distance behind the latter to meet its fellow of the opposite side. The margin of the process bears a series of denticles, some 85-100 in number. These begin a short distance below the hinge as slight, scarcely distinguishable elevations terminating in short, low, parallel ridges on the outer face of the process. These gradually increase in size (pl. 47, fig. 16) to well marked ridge-like denticles, wedge-shaped in outline, with outer and inner angles connected by a slightly lower saddle. Progressively the inner angle of this ridge increases in size, forming a pointed cusp, and predominates over the outer one (pl. 47, fig. 17) so that in the lowermost 20 to 25, the denticle becomes obliquely pyramidal in form (pl. 47, fig. 18) and terminates in a rounded tip.

*Radula* (pl. 48). The pharyngeal bulb in an alcoholic specimen 70 mm. long measured 19 mm. long by 7.9 mm. wide by 7.7 mm. high. The radula flattened on the slide was 7.3 mm. long by 2.4 mm. maximum width, 1.0 minimum width. The tip of the radula sac is concealed in the muscles between the halves of the mandibles and does not extend beyond the surface posteriorly. The radula in a typical specimen is composed of fifteen rows from its anterior oldest end to the angle, five are exposed above from the angle to the sheath, and 26 in the sheath, the last two being rudimentary, making a total of 46 in all. In a radula of 6.65 mm. length, the width ranged from 0.47 mm. at the oldest end to 2.37 mm. at the youngest posterior end. The teeth are arranged in from 34-46 transverse rows, and consist of a median series flanked on either side by from 11-20 laterals. O'Donoghue (1921) gave the number of rows as 35-40, and the laterals as 12 to 6. The last number is very probably a typographical error for 16; so small a number as six laterals in an uninjured row has not been found by me, the minimum being 11. My formula is 34-46 (11-20·11-20).

The median tooth (pl. 48, figs. 1, 2, 3, 4, 5) consists of a stout, short, and broad base, rounded in front, and with the posterior face either straight or very slightly concave, with a short, median, square-like projection corresponding to the basal portion of the hook above. Upon this base is borne obliquely a triangular convex plate, the higher, pointed, posterior portion forming the projecting cusp or hook of the tooth. The oblique sides are concave and bear a series of from 12 to 15 strongly developed pointed denticles. These are much larger and more prominent than in any other species of *Dendronotus* yet described. The anterior border is rounded, slightly concave, or notched

in the median region. The anterior dorsal portion of the tooth is occupied by a sharply defined, shallow, triangular depression corresponding to the outline of the ventral surface of the cusp of the median tooth immediately preceding, which fits down into it in the radula sheath.

In passing from the oldest to the youngest portions of the radula, there is the usual progressive increase in size of all the elements, but the form and proportions remain much the same. Figure 2 of plate 48 shows in dorsal view the oldest median tooth of a large radula. It measures 0.117 mm. in length over all, by 0.114 mm. in width, and bears 13 lateral denticles on either side of the cusp. Figure 1 of the same plate illustrates a similar view of two median teeth of rows 22 and 23, which are close to the anterior margin of the radula sheath. The length of the 22nd median tooth is increased to 0.180 mm., its width to 0.150 mm., while the number of denticles is still 13. The median tooth of the 40th row of this radula measures 0.252 mm. in length, by 0.204 mm. in width, and bears 13 lateral denticles on either side. Figure 4 of plate 48 shows the median tooth of the 32nd row as seen obliquely from above, and figure 3, of the same plate, that of the 34th row in lateral view. The length and character of the lateral denticles are clearly shown, as is also the short and wide base in figure 5.

The lateral teeth in my preparations range in number from 11 to 20, the smaller number being found in the oldest rows as usual. Figure 1 of plate 48 shows the innermost three and four, and the outermost three of rows 22 and 23, which contain a total of 17 laterals on each side of the median tooth. The omitted ones are in all respects similar to the fourth one figured here. The typical lateral consists of a flat elongated base, thin in front and thickened behind where the low, strong, pointed hook arises. The sides are nearly parallel, the anterior end is oblique, and the posterior one slightly widened and rounded. The hook is directed slightly toward the middle of the radula, is rounded, the tip is somewhat blunted, and the whole makes an angle of about  $20^{\circ}$  with the plane of the base. The total length of a typical sixth lateral from the middle of the radula measures 0.264 mm., of which the spine or hook makes up 0.144 mm., the maximum width of the base being 0.048 mm.

The outermost three of four laterals decrease in size rapidly, the outermost one being reduced to a quite narrow base, usually bearing, however, a short distinct spine. A typical outermost one measures 0.150 mm. in total length, 0.016 mm. in breadth and 0.042 mm. in length of the spine alone. Approaching the inner end of the row the base is reduced in length, the hook becoming shorter and proportionately thicker, more erect, and more obliquely directed toward the median line.

The base of the first lateral becomes almost rod-like, being thickened along its outer portion lengthwise and slightly widened at its posterior end where the short, stout, somewhat claw-like hook is borne. Its total length in one of the middle rows is 0.150 mm., its width from 0.030 to 0.036 mm., and the length of the spine 0.042 mm.

As a rule the spines of the lateral teeth are smooth and entirely free from the denticles borne on the outer margin in the other species of this genus. Close examination, however, frequently reveals that the outer margin of the spine of the first lateral in the



oldest 10 to 15 rows may bear a finely serrated edge, or from one to four small pointed denticles. These disappear in the succeeding rows and the larger portion of the radula bears laterals having a simple smoothly rounded spine. In one instance a similar thin serrated edge was found upon the outer margin of the second lateral in the oldest rows, and in another mount the first five laterals were found to bear from one to five small denticles in the oldest six or seven rows. These rudimentary denticles, appearing only in the oldest portion of the radula, evidently indicate the derivation of this species from an ancestral form with denticulate lateral teeth such as are found in such widely distributed circumpolar species as *Dendronotus frondosus* (Ascanius).

*Alimentary system.* The post-bulbar salivary glands are very long and convoluted, extending backward along the oesophagus and anterior part of the stomach. Their ducts pass forward through the nerve ring around the oesophagus and penetrate the dorsal wall of the pharyngeal bulb, opening into its lumen laterally, opposite the anterior angle of the radula.

The broad oesophagus passes backward and downward from the postero-dorsal face of the pharyngeal bulb and dilates into the large thin-walled stomach occupying a position ventrally and to the left, then doubles upward and forward and passes into the intestine, which loops to the right and backward to the anal opening.

The capacious thin-walled stomach is frequently distended with food fragments. In one dredged off Point Reyes, California, it was distended to its full capacity by fragments of a nemertean, some more than 30 mm. in length by 0.8 mm. in diameter. Such fragments were found throughout the stomach and well into the beginning of the intestine.

The liver is divided into three separate lobes, two paired right and left anterior lobes and a single posterior one which extends backward ventrally below the ovotestis to the hinder part of the body cavity.

In its posterior curvature the stomach receives the three separate ducts of the right and left anterior and the posterior lobe of the liver. Each of the lobes has a wide axial cavity, the wall of which is thickly beset with simple and branched secretory alveoli. The anterior lobes on either side continue forward, sending blunt branches into the stalks of the first cerata and extend well up into the stalks of the cerata where they terminate in short rami.

The gastric wall is thin, nearly smooth when distended, and lined with columnar epithelium. At its pyloric end, the wall is somewhat thickened by an increase of muscle fibers arranged to form a narrow circular band surrounding it. The lining epithelium of this girdle is thrown into a closely set series of quite low folds, either parallel and independent or somewhat branched. The length of the folds corresponds to the width of the girdle, some 0.8 mm. The columnar epithelium bears a thin but strong cuticular investment, thickened slightly at the summits of the folds. A similar series of cuticularized folds was first briefly noted by Bergh (1885, p. 30) for *D. arborescens* and seems to be a characteristic structure in the genus, though seldom noted. It is present in all the



Pacific Coast species here described, and it is without doubt homologous to the gastric armature in other Dendronotacea.

Beyond the girdle the pylorus contracts into the intestine, the lining of which is formed into numerous, low, longitudinal folds and a much larger more uniform one, the typhlosole, usually ventral in position.

*Reproductive system.* (Pl. 50, fig. 1.) The *ovotestis* forms a dense lobulated mass overlying the posterior lobe of the liver and extending beyond it. The organ is composed of a great number of densely packed lobules from each of which a delicate duct leads, joining with its fellows to form the ventrally placed *hermaphroditic duct*, which anteriorly expands into the long, cylindrical, hermaphroditic *ampulla* at the posterior face of the anterior genital complex, being looped irregularly against it.

At the anterior end of the ampulla it narrows, gives off the *vas deferens* (*vas.d.*), and passes into the gland complex as the oviduct (*ov.*). The long *vas deferens* is made up of a proximal prostatic portion and a distal muscular duct. The long prostatic segment is made up of closely packed glandular alveoli, completely concealing the irregular loops of the deferent canal into which they open. Near the distal end of the prostate the alveoli decrease in number and disappear, leaving the narrow, much shorter muscular segment, which describes a number of close loops and enters the roomy *preputium* (pl. 50, fig. 1, *p.*). The *glans penis* nearly fills the preputial sac, is large, conical, smooth, entirely unarmed, tapering to a blunt tip.

As the oviduct enters the gland mass it gives off the vaginal duct (pl. 50, fig. 1, *v. d.*) which dilates into the vesicula seminalis, or *spermatheca*, actually forming a spherically dilated sharp bend of the duct. The vaginal duct thence passes directly outward and opens into the large vagina (pl. 50, fig. 1, *vag.*), which opens externally immediately above the opening of the oviduct. The female openings, in a state of complete retraction, lie at opposite ends of a common crescentic atrium; when but slightly turgid or everted they appear to have separate external openings. Into the upper third of the vagina opens a quite small, pear-shaped *bursa copulatrix*, much smaller than the proximal vesicula seminalis. Odhner has found this condition in *D. frondosus* as well as in *D. iris*, and considers it a generic character. The other three species of *Dendronotus* from Monterey Bay, described as new in this paper, likewise all possess this *bursa copulatrix* in characteristic forms.

#### *Dendronotus subramosus* MacFarland, new species

Plate 40, figure 3; plate 46, figures 5-8; plate 47, figures 3-7;  
plate 49, figures 1-3; plate 50, figure 2; plate 52, figures 1, 2

*Body* limaciform, compressed, wider than the foot, the back rounding down into the sides with no indicated boundary other than the line of dorso-lateral appendages. the surface everywhere smooth or with minute low papillae. Cardiac elevation prominent. *Foot* narrow, linear, its anterior end rounded, the tail short and pointed. Margin of *head* rounded (pl. 40, fig. 3), its velar margin marked only by a series of four to six

stout branched processes directed forward, the two nearest the mid-line on either side usually the largest, the next somewhat smaller, and the outermost, when present, quite small, being mere tubercles. The largest of these processes bear short blunt branches given off at a sharp angle to the main stalk; the smallest, outer processes are usually unbranched.

*Rhinophores* stout, erect, inclined slightly forward, the stalk without a basal external process, such as is found in other species of the genus, expanded above into a campanulate sheath the margin of which bears five to seven short blunt processes, the longest on the rear margin, the others progressively shorter toward the front of the sheath edge. The largest of these processes may bear one or more short blunt tubercle-like branches. *Rhinophore clavus* is bluntly conical, perfoliate, with about eight oblique leaves united in front and behind by a low, obscure median ridge.

*Dorso-lateral* papillae usually in six opposite pairs, the stalk stout, erect, dividing into stout subdivisions with short blunt branches. The delicacy and complexity of the branchings is much less than in other species of the genus, the external horizontal ramus being absent in all cases. The first pair of processes is immediately in front of the cardiac elevation, the second close behind it, the remainder spaced at slightly decreasing intervals toward the tail.

*Mouth opening* a vertical slit surrounded by very thick plicated lips. (Pl. 49, fig. 3.) *Anal opening* an inconspicuous pore on dorso-lateral line about midway of the interval between the first and second dorsal papillae of the right side.

*Renal pore* very close above the anal opening, in fact the two have a common exterior orifice.

*Labial armature.* Lips thick, fleshy, glandular, radially plicated. Oral tube thickly glandular, the inner mouth disk convex, its distinct cuticle progressively thickening, modified into a narrow zone of long hair-like filaments. (Pl. 52, figs. 2, 2.)

*Mandibles* reddish brown, the wing ovate, mytiloid, dorsal process well developed, masticatory margin short, bearing an armature of closely set, smooth, transverse crescentic ridges. (Pl. 47, figs. 3-7.)

*Radula* long, rather wide, its formula 56-72 (5-7·1-5-7). Median tooth with thick strong cusp bearing six to ten short denticles. Lateral teeth thin, flat, the inner ones with a short cusp bearing four to seven short sharp denticles. (Pl. 46, figs. 5-8.)

*Reproductive openings* on right side below the dorso-lateral line and somewhat in front of first dorso-lateral process. In contracted condition the opening of the preputium appears at the summit of a small papilla, immediately behind which is a crescentic depression bounded by a plicated border inclosing the opening of the vagina above and that of the nidamental gland below. (Pl. 40, fig. 3.)

*Color* in life. (Pl. 40, fig. 3.) Quite a range of variation is seen in the color of this species. The general ground color of the animal varies from a pale yellow through

deeper yellow to orange, and finally to varying shades of red-brown to dark brown. Very small, pale, lemon-yellow spots may be sprinkled everywhere over the dorsal and lateral surfaces and the appendages. Intermingled with these may be scattered small spots of dark brown and occasionally of golden or reddish brown, or green, or white. The closely set, low conical tubercles are frequently marked by groups of minute lemon-yellow flecks.

Usually four, distinct, longitudinal lines of light or dark brown are seen on the dorsal surface. The outermost of these on either side passes backward from the rhinophore stalk along the dorso-lateral line, connecting the rhinophore and the stalks of the dorsal papillae in succession, being prolonged beyond the last pair to the tip of the tail. Another dark-brown line passes from the inner base of the rhinophore backward to the inner side of the base of each dorsal papilla in succession, merging with the outer dorso-lateral line beyond the last papilla as a more or less distinct median band to the tip of the tail. Anteriorly, these lines occasionally pass up the rhinophore stalks and rarely extend forward to the frontal veil.

The dorsal area between these outer and inner dark bands of either side of the back may be much lighter than the remaining area, giving the appearance of two light stripes edged with darker color. In this lighter area may be found patches of encrusting white, the largest over the heart.

*Dimensions.* Total length from tip of tail to anterior margin of frontal veil ranges up to 40 mm. in the largest specimen yet taken; the foot length reaches 37 mm. in the same specimen, with a maximum width of 3.5 mm. Maximum height of body at the cardiac elevation, 8 mm., its maximum width 5.5 mm. Such large specimens are not common, however, the usual size approximating 25 mm. in total length. Well preserved individuals are shortened in length and usually increased in height by shrinkage, the rhinophores and papillae of the frontal veil and dorsum displaying considerable shrinkage and deformation.

*Habitat.* Common in tide pools all along coast of Monterey Bay at all times of the year, but more abundant during summer months. Very abundant in June, 1923, from Large Tide Pool, Point Pinos, to Cabrillo Point where it was found living upon the hydroids covering the fronds of *Macrocystis* and the holdfasts of the large alga ("sea oak") *Cystoseira*. Many egg bands of a pale-pink color, eggs in a continuous round strand looped alternately above and below. This species is also taken northward less abundantly as far as Humboldt Bay and southward to Newport Bay.

#### EXTENDED ANATOMICAL DESCRIPTION.

*Alimentary system.* The oral tube is short, the external lips surrounding the inverted-T-shaped mouth opening are fleshy and radially plicated. They are closely set with long tubular labial glands extending deep into the sub-epithelial tissue. Within the external opening the mouth tube dilates and is nearly filled by the convex mouth disk

overlying the anterior end of the mandible. Its external surface is covered by a low cuboidal epithelium, bearing a quite thin cuticular layer at the peripheral portion which thickens as the central mouth opening is approached, and in the inner surface of the mouth tube becomes very thick, three to four times as thick as the epithelium cells producing it. Around the margin of the inner mouth opening the thickened cuticle splits up into a zone of long hair-like filaments, their bases occupying a shallow marginal groove. (Pl. 52, figs. 1, 2.)

*Mandibles.* (Pl. 47, figs. 3-7.) Reddish brown near hinge, lighter behind, the wing ovate, mytiloid, thin, arched, its widest part slightly more than one-half the length; dorsal process curving obliquely backward, well developed, thicker below and grooved externally, the apex rounded. A thin, triangular, wing-like expansion joins the lower half of the process to the dorsal margin of the horizontal wing. Masticatory margin (pl. 47, fig. 5) short and curved backward, its armature a series of closely set, transverse, crescentic plates some 120 in number, the zone narrowest at the hinge (pl. 47, fig. 4) and increasing in width downward, the margin of plates smooth or nearly so. (Pl. 47, figs. 6, 7.)

*Radula.* (Pl. 46, figs. 5, 6, 7, 8.) Long, tapering, the lower limb one-half the length of the upper; 56 to 72 rows of teeth, the radula formula being 56-72 (5-7-1-5-7).

Median tooth large, its base cuboidal, high, two to three times as wide as long, the anterior surface slightly concave, the posterior convex, the upper surface nearly horizontal, arched from side to side, slightly convex laterally, projecting beyond the body and prolonged posteriorly in a thick, strong, median cusp, anteriorly deeply notched to receive the cusp of the preceding tooth. The median tooth from the first two rows keeps the same general shape of base and cusp but is much reduced in size by wear. The lateral margins of cusp bear six to ten short denticles, decreasing in size toward the tip.

Lateral teeth five to seven, thin, flat, the bases quadrangular. Posterior ends of the teeth of the inner four or five rows elevated somewhat into a short, sharp, triangular cusp overlapping the following row of laterals and bearing on its outer, oblique margin from four to seven short, sharp denticles. The base of the first lateral is one-third to one-half the width of the second, its cusp is short, and the denticles three or four in number, nearly equal the main cusp in size. The cusp of the second lateral is the longest of the series, its denticles six or seven. The cusp of the third lateral is shorter and that of the fourth much reduced, scarcely longer than its denticles. The fifth and sixth row are reduced to flattened bases without cusps, as a rule, the sixth much narrower. The seventh, when present, is little more than a rudiment, often appearing as a continuous, narrow, chitinous strip along the margin of the radula.

The *oesophagus* passes downward and backward to the left from the pharyngeal bulb and dilates into the anterior part of the roomy stomach.

The paired *post-bulbar salivary glands* form a loosely ramified complex of branching tubules close behind the pharyngeal bulb dorsal to and surrounding the

oesophagus. The main salivary duct from each side passes forward through the nerve ring and opens into the pharyngeal cavity through its dorso-lateral wall opposite the anterior angle of the radula and immediately in front of the exit of the oesophagus.

The *stomach* curves abruptly upward and receives the three hepatic ducts, beyond which the gastric wall is thickened by a zone of circular muscle fibers, and the ciliated epithelium is replaced by a low columnar form bearing a well developed, though thin cuticle. The epithelium forms a series of low longitudinal ridges or folds, occasionally divided transversely into blunt papillae, the summits of which bear somewhat thicker cuticle than the intervals between them.

The whole forms a rudimentary gastric armature or triturating apparatus similar to that found in the three other species of Pacific Coast *Dendronotus* and undoubtedly homologous to that found in *Duvaucelia*, *Marionia*, and other forms of the Duvauceliidae.

Beyond the gastric girdle the distal stomach decreases in size and passes into the intestine which loops forward and to the right below the heart and passes backward as a slender tube to the anal opening midway between the first and second cerata of the right side. Just distal to the gastric girdle a low internal fold appears which increases in size and passes along the ventral wall of the intestinal loop and gradually dies away beyond it. This is the typhlosome, and upon its disappearance the lining of the intestine develops a number of low, parallel, longitudinal folds which continue back to the anus.

The *liver* is divided into three parts, two *anterior* and a median *posterior*. The anterior lobes open widely into the stomach on its right and left sides, the posterior lobe through the hinder wall. The lobes are thin walled and irregularly saccular, each with a wide central lumen into which large, though shallow, diverticula open bearing in turn smaller irregular alveoli.

The anterior rami send off branches to the first pair of cerata and terminate in the stalks of the rhinophores by blunt short divisions. The posterior lobe, the largest of the three, passes back ventrally below the ovotestis to the hinder end of the body. It sends no branches to the posterior cerata.

*Reproductive system.* (Pl. 50, fig. 2.) The ovotestis is made up of a large number of closely packed, rounded or somewhat pyriform lobules lying above the liver in the posterior part of the body. Each is made up of a central rounded follicle filled with developing spermatogonia, lining the periphery of the follicle, to nearly mature sperm in the central part. Surrounding each of these male follicles is a closely set series of small alveoli containing developing ova, each alveolus being a diverticulum from the central follicle. From each of these lobes a thin-walled duct arises which joins its fellows and passes forward.

This hermaphroditic duct passes forward from the ovotestis and expands into the short, crescentic, or sausage-shaped ampulla (*h. a.*) which forms a close loop upon the inner face of the anterior genital complex. At its anterior end the duct narrows, gives



off the vas deferens (*v. d.*) and, continuing as the oviduct (*ov.*), opens at once into the thin-walled, ciliated fertilization chamber of the glandular mass.

The proximal muscular segment (*m. seg.*) of the vas deferens is quite short and widens almost at once into the greatly enlarged prostatic portion (*pr.*), its proximal limit being marked by a closely crowded ring of 10 to 12 alveolar glands (*alv.*), the whole group of alveoli measuring about 1 mm. in diameter. The lining epithelium is high columnar in form, with deeply basophile basal nuclei, the cell being packed full of fine granules.

Beyond the group of alveoli, the vas deferens is coiled irregularly upon the anterior face of the complex and tapers gradually to the base of the large preputial sac with a length of approximately 5 to 6 mm., the high columnar cells becoming transformed into low cuboidal ones, the outer muscle layers increasing progressively in thickness.

The preputium (*p.*) is a very large thin-walled sac inclosing the long irregularly coiled and looped glans penis (*gl. p.*). The latter is tapering, blunt, and unarmed, its maximum basal diameter about 0.4 mm., the total length approximately one-third that of the whole animal.

The vagina (*vag.*) is long and slender. It receives the duct of the short pyriform rudimentary bursa copulatrix (*b. c.*) a short distance, 6 mm., from the external opening, and the very short, nearly sessile, spherical spermatheca (*spth.*) near its proximal end. It communicates with the fertilization chamber just beyond the opening from the spermatheca by a short and slender vaginal duct (*v. d.*). In a large specimen the total length of the vaginal duct and vagina is about 3.5 mm., the diameter of the spermatheca 0.9 mm., the total length of the bursa copulatrix and its duct 0.45 mm., its diameter 0.2 mm.

*Central nervous system.* (Pl. 49, figs. 1, 2.) The central ganglia are united in a close ring around the oesophagus close to its emergence from the pharyngeal bulb. In figures 1 and 2 they are shown in lateral and in dorsal aspects. The cerebral and pleural ganglia, rounded and of nearly equal size, are closely fused together. The cerebral commissure is very short and broad; close below the cerebro-pleural ganglia on each side is the larger spherical pedal ganglion united to them by the very short cerebro-pedal and pleuro-pedal connectives.

The conspicuous optic ganglion lies ventro-laterally to the hinder part of the cerebral ganglion, to which it is united by a short connective. From the optic ganglion the slender optic nerve passes forward to the eyes located below the base of the rhinophores, deep below the integument, at the level of the upper surface of the pharyngeal bulb. Behind the optic ganglion is the otocyst or statocyst, connected by short and delicate nerve fibers to the hinder part of the cerebrum. The ovoid buccal ganglia (p. 49, figs. 1, 2) lie in front of the cerebro-pleural ganglia and close below the oesophagus upon the dorsal surface of the pharyngeal bulb. They are joined together by a buccal commissure nearly equal in length to the long diameter of the buccal ganglia. The cerebro-buccal commissures as shown in the figure are relatively short.



**Dendronotus venustus** MacFarland, new species

Plate 40, figure 2; plate 46, figures 9-12; plate 47, figures 1, 2;  
plate 49, figure 6; plate 50, figure 3; plate 52, figures 3-6

*Body* limaciform, slightly compressed; dorsum somewhat flattened and well marked, rounded at the margins into the sides, in front sloping rapidly down to the frontal veil, surface smooth or with thickly set small conical elevations which sometimes extend over to the surface of the oral margin of the lips. Heart forms a rounded elevation as is true of the other Monterey species. *Foot* narrow, rounded in front, not sharply set off from the body wall, narrowing rapidly behind into the short pointed tail. *Frontal veil* well defined, bearing four to six, or even eight, branched tapering processes (pl. 40, fig. 2). Four of these, two on either side of the median line, are large and well developed, and are usually constant, the innermost one the larger and more branched. Between the first and second, and the third and fourth of these processes, a smaller less branched process may be borne, and at the outer end of the veil another smaller one may occur, these smaller ones being quite variable both in size and in occurrence. The branches of the velar processes are simple, forked, or in the largest ones, bear short subdivisions. (Pl. 49, fig. 6.)

*Rhinophores* (pl. 40, fig. 2) large, stout, as high as, or higher than the first dorsal papillae. Clavus conical, perfoliate, with 10 to 14 leaves, retractile within flaring (campanulate) sheaths, bearing five branched marginal processes, the largest postero-medial in position, the others shorter and less ramified on outer and inner margins of the sheath. Near the base of the outer surface of the cylindrical stalk of each is borne an external short horizontal process, bearing a number of short branches toward the tip.

*Cerata* in five or six opposite pairs, erect, branched into short, rather stiff subdivisions. These are spaced at approximately equal intervals along the dorso-lateral margin, the first pair about one-fourth of the body length from the anterior end of the head, the smaller posterior pairs progressively closer together. All cerata and the rhinophores receive branches from the liver.

*Eye* behind the rhinophore, lateral to the anterior end of the cerebral ganglia, suspended in connective tissue. The eyes show through the body above and slightly behind the reproductive openings, directed upward beneath the liver lobe.

*Anal opening* on right dorso-lateral side, half-way or slightly behind the midway point between the first and second dorsal cerata and at the summit of a low papilla (opposite the summit of the cardiac elevation). Renal opening immediately above and close to anal papilla. (Pl. 52, fig. 6.)

*Labial armature* (pl. 52, fig. 3), a ring of long, narrow, flexible rodlets.

The *mandible* (pl. 47, figs. 1, 2) body is mytiloid in form, a strong dorsal prolongation, the masticatory margin strong, bearing from 27 to 40 ridge-like denticles.

*Radula* formula 28-34 (6-7·1·6-7); median teeth large and strong, 10 to 12 pointed denticles. Lateral teeth thin, elongate, flattened plates, the posterior margin prolonged into a strong point bearing denticles. (Pl. 46, figs. 9-12.)

*Reproductive openings* close together on the middle of the right side, midway of the interval between the rhinophore and the first dorsal ceras.

The general *body color* is a clear translucent gray, the surface everywhere, except the sole of the foot, with irregular patches of yellow-green to a brown-green which forms an almost continuous band along the dorsal lateral line connecting the dorsal cerata. Scattered between these are spots of olive to pale green and pale chrome yellow to bright orange. The low conical papillae are tipped with chrome yellow. Rarely these papillae form a ridge down the rhinophore stalk along the dorsal lateral line to the first cerata. The liver branches show as light green deepening to a brown, while the terminal tips of the cerata branches have many flecks of a bright yellow. In many specimens, a series of encrusted transverse white spots of varying size occupy the mid-dorsum in the intervals between the successive pairs of cerata, decreasing progressively in size from anterior to posterior. (Color plate 40, fig. 2.)

*Dimensions.* The largest living specimens taken reached a length of 30 mm., width 4.5 mm., and maximum body height in cardiac region of 7 mm. More common specimens were from 16 to 20 mm. long, with maximum width of 3 to 4 mm. and height of 3.5 to 6 mm. The maximum length of the cerata was 2.5 mm., of the rhinophores including the sheath processes 6 mm., the clavus 2 mm. The range is from small specimens 9 mm. long to the largest of 30 mm.

*Habitat.* Hydroids are the feeding grounds for *Dendronotus*. A striking similarity of their forms with the branching of the cerata exists. *Dendronotus venustus* occurs abundantly in Monterey Bay at Point Pinos and Cabrillo Point in open pools and clefts of rocks, most frequently on hydroid-bearing fronds of *Macrocystis* and holdfasts of (the common "sea oak") *Cystoseira*. Specimens were taken from the wharf piles, bottoms of fishing boats, and abundantly from the hydroids of the Bell Buoy off Cabrillo Point. The author collected a few at Crescent City and Morro Bay, and G. E. MacGinitie obtained a small specimen from Newport Bay. This seems to mark the known southern range. Eggs laid in aquaria at various times from June to September, the nidosome an irregular band of capsules loosely looped back and forth transversely of its length.

#### EXTENDED ANATOMICAL DESCRIPTION.

*Alimentary system.* The external lips surrounding the mouth are closely set with long, tubular glands. The lip disk is covered by a thin plate of cuticle more delicate than in *D. albus* and *D. subramosus*. The oral opening is a vertical slit surrounded by thick muscular lips, the epithelium of which bears the cuticle thinning away externally and within the mouth tube continuous with the masticatory margin of the mandibles from which it is readily separated. At the anterior upper end of the lip disk is a

clearly defined median longitudinal furrow; a less clearly marked one is similarly located at the posterior margin, the remainder of the surface of the disk is strongly arched. The opening is surrounded by a narrow zone of cuticle differentiated into short blunt rodlets which become reduced to mere plates in the anterior and posterior regions of the tube, reaching their greatest development on the lateral anterior faces. The longest of these rodlets measure 0.015 mm. in length by 0.00725 mm. in diameter. (Pl. 52, fig. 3.)

Outside of this prehensile collar of rodlets on the free surface of the lips is borne an outer narrow zone of rodlets which are much longer than the inner zone, reaching a length of 0.035 mm. and width of .003 mm.

These form a complete ring and are evidently much more flexible than the inner ones; those at the anterior and posterior regions are filamentous and very slender, the whole series presenting a very disheveled appearance in the preparation.

The *oesophagus*, emerging from the pharyngeal bulb, bends sharply to the right side and passes backward to the anterior end of the stomach. The stomach loops downward on the right, doubles sharply upward, passes transversely over the dorsal face of the viscera, and narrows abruptly into the intestine which loops on the right side to the anus.

The *salivary gland* (post-bulbar gland) opens by a paired duct on either side into the anterior pharyngeal cavity opposite the anterior angle of the radula. The slender ducts pass backward through the nerve ring lateral to the oesophagus and ramify to the branching tubules of the gland immediately posterior to the bulb and loosely surrounding the oesophagus, extending back as far as the stomach.

*Mandibles.* Figure 1 of plate 47 shows the inner face of the right mandible, mytiloid in form, extreme length 0.825 mm., the concave inner face bearing a very low, strong, grooved, dorsal prolongation with a rounded tip. A strong ridge extends from the hinge for 0.24 mm. The masticatory margin strong, curved, bearing 27 to 40 transverse ridge-like denticles, the outer surfaces of the larger and younger ones roughened with minute spines. The masticatory process from the tip to the hinge is 0.315 mm. in length and is united with the mandible by a wide triangular vaulted expansion. (Pl. 47, fig. 2.)

*Radula.* (Pl. 46, figs. 9-12.) The specimen used was 11.7 mm. long. Thirty-one teeth in the radula, 14 to the angle, 17 beyond. Total length 1.328 mm.; formula 28-34 (6.7.1.6-7). Median tooth large, strong, its base quadrilateral, bearing a strong triangular cusp directed upward and backward at an angle of about 45° with the base. Strongly denticulate, 10 to 12 denticles on each side, being long and pointed, the longest one-fourth the total length of the cusp; decreasing in length as the tip is approached, dying away in irregular serrulations.

Lateral teeth six, rarely seven or even eight, each consisting of a thin, elongate flattened plate, its posterior thickened margin elevated and prolonged into a strong point curved toward the mid-line of the radula, the outer border of the cusp bearing a series of four or five sharp denticles; the innermost lateral has a diminished apex and

its two to three denticles are nearly equal to it in size. The outermost or sixth lateral is quite narrow and almost rudimentary, its small apex nearly straight, smooth, or with faint denticulation. When seven or eight laterals are present, the outermost ones are reduced to flat plates with only vestigial cusps. (Pl. 46, fig. 9.)

The *stomach* is lined with a high columnar ciliated epithelium which is modified into low longitudinal folds. At the posterior curvature of the stomach it receives the wide biliary ducts from the anterior right and left lobes and from the median posterior lobe. Close beyond their entrance, the clear ciliated gastric epithelium decreases one-half in height, loses its cilia, and becomes transformed into a low columnar type with a thin but distinct cuticular margin. The outer muscular layer of the gastric wall becomes thickened by the development of circularly disposed muscle fibers, forming a narrow zone. The lining is thrown into low irregular longitudinal folds, the whole structure forming a rudimentary gastric girdle such as is more strongly developed in *D. iris*, *D. subramosus*, and *D. albus*. (Pl. 52, figs. 4, 5.)

*Liver* in three divisions, two anterior and one median posterior. Ducts from the anterior right and left lobes pass forward, sending rami into the first ceras of each side, terminating in the sheath of the rhinophores, extending into the larger processes.

From the ventral posterior curvature of the stomach, the large posterior lobe of the liver passes backward beneath the ovotestis. It sends dorsal branches directly upward between the acini of the hermaphroditic gland to each pair of the posterior cerata in succession, a condition not found in *D. iris*, *D. subramosus*, or *D. albus*.

*Reproductive system.* (Pl. 50, fig. 3.) The parts are somewhat displaced and spread to make clear their relations. The lobules of the ovotestis fill the dorsal half of the pseudocoelom behind the cardiac region, leaving the ventral portion free for the posterior lobe of the liver. The lobules are structurally similar to those of the other Pacific Coast species of *Duvauclia*, each consisting of a central pyriform or spherical follicle crowded with spermatozoa, its periphery closely set with small spherical ovogenic follicles. From each of the lobules a narrow duct arises and joins other similar ones to form the hermaphroditic duct which courses forward to the anterior genital complex, on the inner posterior face of which it dilates into the crescent-shaped hermaphroditic ampulla. (Pl. 50, fig. 3, *h. amp.*) Emerging from the distal end, the narrow duct gives off the vas deferens and opens into the cavity of the nidamental glands (fertilization chamber), receiving, as it enters, the proximal end of the vaginal duct.

The proximal end of the vas deferens is at first very short and muscular. Dilating into the central cavity of a group of five to seven spherical alveoli arranged in a circle about it (pl. 50, fig. 3, *pr.g.*), the much widened vas deferens continues as its prostatic segment very long and convoluted upon the upper anterior face of the complex. In figure 3 of plate 50, the ducts are represented in their true relative proportions but are separated so that their relations may be better shown.

The prostatic segment of the vas deferens is thick walled, made up chiefly of a lining of high columnar gland cells with dense basal cytoplasm and nuclei.

The distal fourth of the vas deferens (pl. 50, fig. 3, *m. seg.*) becomes narrowed into a tube with small lumen and muscular walls, continues as such to the base of the preputium where it enters the dilated proximal end of the glans penis and continues to its tip.

The glans is long, slender, and tapering, pointed at the tip, unarmed, its basal part showing an irregular, somewhat folded contour which disappears when the organ is extended from the male opening. Its surface is covered with low cuboidal epithelium bearing very long cilia, twice as long as the height of the cells themselves. (Pl. 50, fig. 3, *gl. p.*)

The vagina (pl. 50, fig. 3, *vag.*) is long and tapering. Upon its proximal third it bears a small, as if rudimentary, bursa copulatrix (*b. c.*), beyond which the vagina tapers into the vaginal duct. It bears, just before its entrance into the gland complex, a small pyriform spermatheca (*sph.*) 0.5 mm. in diameter by 0.8 mm. long, which opens widely into the duct, being almost a dilation of the proximal end of the vagina.

#### *Dendronotus albus* MacFarland, new species

Plate 40, figure 1; plate 46, figures 1-4; plate 47, figures 8-11; plate 48, figures 7, 8;  
plate 49, figure 5; plate 50, figure 4; plate 51, figures 6, 7

*Body form* elongate, compressed, tapering rather rapidly behind into the short pointed tail, in front sloping slightly to the blunted head. *Dorsum* smooth, arched, rounding off into the sides with no indicated boundary line save in the position of the arborescent cerata, arranged dorso-laterally in a single row on each side. *Foot* narrow, rounded in front, not sharply marked off from the body, tapering rapidly to the tail. (Pl. 40, fig. 1.)

*Frontal margin* (pl. 49, fig. 5) bears upon a low horseshoe-shaped velar elevation four, long, branched, cylindrical, tapering processes arranged symmetrically, two upon either side of the median line. The inner longer pair are slightly lateral to the line of the rhinophores; external to these a second pair, somewhat shorter, are to be found. Each of these bears a variable number of short, irregular, blunt branches from base to tip mainly on the anterior surface, diverging but slightly from the main stem. Many of these in turn may be slightly branched or tuberculate. Inferior to this series of main processes, and especially slightly in advance of them toward the lip disk, may occur other similarly branched or tuberculate, much shorter appendages in varying number.

Dorso-lateral *cerata* four to five pairs, opposite, non-caducous, arranged in a single row along either side of the back. The first pair is immediately in front of the cardiac elevation, the second just behind it. The first and second pairs of processes are elaborately arborescent, the remaining ones decreasingly so in succession. In the anterior pairs each appendage exhibits three main rami. A short distance above the base, a nearly horizontal branch is borne, directed outwardly. Above this the main stem usually divides into two nearly equal, diverging, erect branches, each of which bears a number of shorter subdivisions.



*Rhinophores* long and stout, well separated, near the dorso-lateral body margin, with perfoliate retractile clavus bearing 12 to 14 leaves. Midway up the cylindrical rhinophore stalk, a simple, short, external branch, directed obliquely upward, is given off. The margin of the dilated campanulate sheath is prolonged into five slender tapering processes, the longest of which is posterior, often reaching one-half the length of the whole organ. The front pair are short, the second intermediate in size. All the processes bear several short tapering branches similar to those of the frontal veil, and all directed obliquely upward. *Eyes* far forward at the end of a long nerve.

*Mouth opening* vertical, surrounded by a thick glandular circular lip notched at posterior margin. (Pl. 49, fig. 5.)

*Labial armature* (pl. 51, figs. 6, 7) an inner ring of short, slender, blunt cuticular rodlets, 0.005 mm. in diameter and up to 0.3 mm. long. *Mandibles* (pl. 47, figs. 8, 9) thin, delicate, and transparant, deepening to a pale yellow in the slightly thickened hinge region. *Radula* nearly colorless, teeth in 36 to 38 transverse rows, median tooth strong with triangular cusp bearing inconspicuous denticles. Laterals seven to nine on each side, thin and transparent.

*Reproductive openings* close together, midway on the right side, below and slightly in front of the base of the first dorsal ceras. Anal opening high on the right side nearly midway between the base of the first and second dorsal cerata. Close in front of it is the minute renal pore.

*Color.* (Pl. 40, fig. 1.) The body color in life everywhere a clear translucent gray, the branches of the cerata, rhinophore sheaths, and velar processes pure white except at their bases where this becomes modified with the body gray. Above the white, as the process narrows, is an orange-yellow stripe becoming a dark-brown termination in a clear tip. The white and color are below the surface which is difficult to show in such delicate structures. The rhinophore plates are a delicate brown, the same color sometimes found in groups of small spots at the base of the rhinophores and on the dorsum between cerata or entirely absent.

A narrow median line of white extends along the back, from opposite the fourth cerata to the tip of the tail. The internal organs show through the integument as a rose-brown elongated area.

*Dimensions.* The length in life ranges up to 30 mm. maximum, the width 3 to 4 mm., and the height 5 mm. The foot in the same specimen measured 24 mm. in length by 2 mm. in greatest width. The longest velar processes were 5 mm. in length, the lateral ones 2.5 mm.

Alcoholic specimens used in dissection were 17.6 to 21.6 mm. in length.

*Habitat.* This strikingly beautiful species is rather rare in the Monterey region, and has been taken during the summer months in the neighborhood of Point Pinos between tide marks upon kelp or floating freely in rocky pools. It does not bear confine-



ment well and soon dies in aquaria. The nidosome is a narrow white band looped back and forth usually in a simple spiral.

#### EXTENDED ANATOMICAL DESCRIPTION.

*Alimentary system.* Foot narrow, the anterior end rounded, the sole abundantly provided with short tubulo-alveolar mucous glands especially at the anterior end. The mouth opening is oval, the posterior margin and sides smoothly rounded, while the upper anterior region is indented by a longitudinal groove. (Pl. 51, fig. 6.)

The *mouth tube* is thickly beset with short tubular glands throughout its whole length back to the dilatation in front of the inner lips bounding the opening of the pharyngeal bulb. As is shown in plate 51, figure 7, representing a horizontal section through one side of the inner opening, the lips are covered by a thick cuticle as the mandibles are approached, which thins away somewhat externally and breaks up into an incomplete circlet of blunt flexible rodlets. This labial armature is interrupted above by a narrow cleft in which the cuticle thins away and the rodlets are carried upward and forward toward the margin of the zone. (Pl. 51, fig. 7.) The cuticle of the inner surface reaches a thickness of 0.22 mm., the columnar epithelial cells producing it measuring 0.08 mm. in height. The longest rodlets approximate 0.3 mm. in length with a diameter of 0.005 mm.

*Mandibles.* (Pl. 47, figs. 8, 9.) The main plate is convex, oval, mytiloid, horizontal, narrowing toward the anterior end. An anterior wing-like dorsal process, deeply grooved externally, is attached above the hinge, and is directed obliquely upward and backward. Its posterior margin is continued backward as a thin concave wing attached below along the anterior third of the dorsal margin of the horizontal plate of the mandible. From a specimen 21.6 mm. long the mandible plate was 2.6 mm. long, 1.2 mm. wide, dorsal process 1.25 mm. long, 1.6 mm. high at top of dorsal process.

Plate 48, figures 7, 8, show the mandibles united at the hinge. The anterior portion of the space between them is lined by a thin chitinous membrane following laterally the inner face at a short distance from it. Medially, the two lateral sacs meet, the space between their medial walls being occupied by the radula. Posteriorly, a V-shaped groove at the bottom of the oral cavity is formed by these cuticular membranes.

Masticatory process short, 0.8 mm. long, its ventral tip curved sharply backward, bearing an armature of 70-80 short transverse plate-like ridges (pl. 47, figs. 8, 9), the longest below and decreasing above, being finally reduced to obscure flattened denticulations 0.09 mm. from the hinge. The surface of these ridges is smooth above, becoming slightly roughened toward the tip as seen under magnification. (Pl. 47, figs. 10, 11.)

Each elevation is borne upon a narrow plate-like division of the masticatory process extending back from the margin, becoming flatter, thinner, and higher toward

the end. The margin is recurved strongly on its outer face, becoming less so toward the tip where the plates curve around on the outer face.

*Radula.* (Pl. 46, figs. 1-4.) In a specimen 21.6 mm. long, the pharyngeal bulb measured 3.2 mm. long, 2.2 mm. maximum width, 1.6 mm. high.

Radula teeth in 36-38 rows, 20 in the lower limb to the angle of the radula, two from the angle to the anterior margin of the sheath, 16 from that point to the end of the radula sac, the formula being 36-38 (7·9·1·7·9).

The basement membrane very thick in the median area of the radula, the base of the median teeth fitting down into deep sockets; laterally this thins away rapidly beneath the pleural teeth.

Median tooth light yellow, large, and strong, its over-all length and breadth about equal. Base, a transverse oval, approximately as wide as long. The dorsal surface is prolonged upward and backward into a bluntly triangular convex cusp, three-fourths as long as broad. The lateral margins bear 16 to 20 inconspicuous blunted denticles, scarcely more than serrulations, sometimes most developed near the tip. The median anterior surface bears a deep depression in which rests the cusp of the preceding tooth. Plate 46, figure 3 (oblique view) shows the lateral anterior angles of the dorsal surface overlapping the base of the preceding tooth.

Lateral teeth seven to nine on each side, thin, and transparent, the rectangular base flat; its inner posterior margin becomes thickened in the innermost five or six teeth and is prolonged obliquely upward as an elongated slightly curved cusp at the inner angle, longest and strongest in the fourth and fifth laterals. On the outer basal margin of this cusp, five to seven sharp denticles are borne. The innermost two teeth have the cusp short. The outermost three or four laterals have the cusp rudimentary or absent and the denticles are reduced to irregular serrulations, while the base becomes narrowed and entirely flat.

*Dimensions.* In a specimen 17.3 mm. long, the median tooth, row 30, has measurements as follows: length .102 mm.; width .150 mm.; length of cusp .078 mm.; width .114 mm. The fourth lateral, 30th row, measures: length .096 mm.; breadth .018 mm.; cusp .06 mm. long.

The posterior pharyngeal (bulbar) salivary glands consist of one pair, their ducts passing through the nerve collar and entering the dorsal side of the bulb close behind the exit of the oesophagus. The glands are compound tubular in form and present close branchings around the oesophagus and the central nervous system at the posterior end of the pharyngeal bulb.

Into the anterior stomach open the two wide biliary ducts in front and the single one behind. The light-brown, thin-walled, saccular liver is in three lobes, two anterior and one posterior. The lobes have a very large roomy cavity bounded by a thin epithelial wall which is unfolded irregularly into diverticula and alveoli of irregular extent. The anterior lobes send fine terminal branches up into the bases of the first pair of cerata, the rhinophore sheath, and its two posterior processes. The posterior lobe lies beneath the lobules of the ovotestis throughout its entire extent and sends a branch to

the second ceras on each side, but to none of the remaining posterior cerata as is the case in *Dendronotus venustus*.

Immediately behind the openings of the liver ducts, the wall of the stomach is increased in thickness by a band of strong circular muscles, and its lining is thrown into low longitudinal folds, the columnar epithelium bearing a moderately thick cuticle which is increased at the summits of the ridges, producing a triturating mechanism somewhat similar to that in *Duvaucelia*. The lining ridges thus formed are chiefly transversely subdivided into short rows of conical papillae, each tipped by a somewhat thickened cuticle which thins away but does not disappear as it covers the depressions between the papillae.

*Reproductive system.* The very numerous lobules of the ovotestis occupy the posterior half of the body immediately above the hinder half of the liver. Each lobule consists of a large, somewhat pyriform sac containing spermatozoa in various stages of development, and is closely set on its periphery with small ovigerous alveoli (producing ova). From each lobule a duct leads into the main hermaphroditic duct which passes forward to the hermaphroditic ampulla upon the inner face of the anterior genital complex. (Pl. 50, fig. 4.)

From its anterior end, its short continuation gives off the vas deferens (*v. d.*) and, as the oviduct (*ov.*) passes into the fertilization chamber of the complex. At its entrance it receives the vaginal duct (*v.*) which bears the spherical almost sessile spermatheca (*sph.*), and continues as the vagina to the external opening near which it receives the small, pyriform bursa copulatrix.

The slender vas deferens soon dilates into its prostatic proximal portion, a close disk-like circle of some ten small spherical glandular alveoli with wide openings, from which the much thickened vas deferens tapers, as a muscular tube about 1.5 mm. in length, to the base of the preputial sac (*v. d.*). The contained glans is unarmed, short, nearly straight, tapering to a blunt tip (*p. o.*). In *D. albus* the glans is much shorter and straighter, not being thrown into coils or loops in order to be contained in the preputium. It is of conical form measuring 0.25 mm. in greatest diameter and 1.2 mm. in length.

The four Pacific Coast species of *Dendronotus* herein described, *D. iris*, *D. subramosus*, *D. venustus*, *D. albus*, show clearly different characters which separate them from each other, and a comparison with text figure 39 of Odhner's masterly work upon the Dendronotacea (1936, p. 1106) will demonstrate their specific separation from *D. frondosus* of northern waters.

They are markedly different in color pattern, external configuration, and internal structure, aside from definite differences in the biting margin of the mandibles and radulae. The details of the reproductive ducts for each, especially of the vas deferens, are most noteworthy. These things can be recognized and compared at a glance in the figures of the plates illustrating the descriptions of the four species.

## Family FIMBRIIDAE [=TETHYIDAE]

Genus *Chioraera* GOULD

*Chioraera* GOULD, 1852. U.S. Exploring Expedition, vol. 12, pp. 309-310, pl. 26, fig. 404.

*Diagnosis.* "Corpus limaciforme; caput enorme, pedunculatum, semiglobosum; paginâ ventrali discoideâ: ore longitudinali, seriebus binis cirrhorum cincto: tentaculae cephalicae foliatae, retractiles; lobi branchiales flabelliformi, serie uncâ utrinque ordinati: foramen generativum ab anali remotum, ferè dorsali."

*Generic history.* In 1829 Rang described a new genus belonging to the family Fimbriidae with the type species *Melibe rosea* Rang, from Cape of Good Hope. Some 12 additional species have since been added, all from the Indian or Pacific waters, the genus apparently not occurring in the Atlantic. In all of these, for which satisfactory anatomical details have been recorded, no radula is found, but a pair of unusually strongly developed mandibles are present. Their existence in Rang's genotype has recently been verified by Mme. Pruvot-Fol (1932).

Gould described the new genus *Chioraera* in 1852 from the coast of the State of Washington, with the type species *Chioraera leonina* Gould, a form related to *Melibe* and considered congeneric with it by Bergh (1892, 1904), O'Donoghue (1922, 1926), Agersborg (1921, 1923), and others. Two other species from Puget Sound region and vicinity, *Melibe pellicida* Bergh and *Chioraera dalli* Heath, 1917, are without doubt identical with *C. leonina* Gould. In all of these, radula and mandibles are clearly absent, and no differentiated pharyngeal bulb is developed, while in all adequately known species of the genus *Melibe* strong mandibles are present. The presence or absence of such important organs as mandibles is certainly to be regarded as of generic significance and, until their variable occurrence or absence can be shown in some single species of *Melibe*, the two genera *Melibe* and *Chioraera* should be considered distinct.

*Chioraera leonina* Gould is a nudibranch mollusk found in eastern waters of the Pacific from Alaska to the Gulf of California. It belongs to the group Aeolidaceae, or Cladohepatica, and to the family Fimbriidae, represented in the Mediterranean by *Fimbria fimbria* (Linnaeus), or as more commonly termed, *Tethys fimbria* Linnaeus.

*Chioraera leonina* Gould

Plate 41, figures 1-7; plate 54, figures 1-10

*Chioraera leonina* GOULD, 1852. U.S. Exploring Expedition, vol. 12, pp. 309-310, pl. 26, fig. 404.

## EXTERNAL DESCRIPTION OF LIVING ANIMALS.

*Body* limaciform, smooth, not at all depressed, slightly compressed laterally, rounded above, tapering gradually from head to tip of the very short bluntly rounded tail.

*Head* separated from the body by a narrow neck, rounded, enormously expanded into a transversely elliptical hood, the dorsal surface arched, the ventral concave, the margins curved downward, forming a large cavity in the posterior median line of which opens into the longitudinal mouth borne upon a low elevation.

The head margin bears two series of slender processes or cirri, the outermost one has the longer processes, 2 mm. in length, with shorter ones, one-half as long, alternating quite regularly between the longer ones, all directed outward from the margin. Within this series is one with more numerous cirri borne upon the inner margin directed inwards in the plane of the opening of the hood. They are arranged at equal intervals, about one-half to one-fifth the length of the longest of the outer series, laterally becoming shorter as the median line is approached, where there is a slight notch on the posterior margin (pl. 41, fig. 2). The inner series has 117 short cirri, while there are about 54 in the outer circle of this specimen. As seen by reflected light, a delicate white axial strand, or tube, extends from the submarginal ring encircling the cowl to near the tip of each cirrus.

*Rhinophores* (pl. 41, fig. 1) widely separate, 10 mm., borne well in front upon the dorsal surface of the head; the stalk long, cylindrical, its inner margin bearing a thin, triangular, sail-like expansion with undulating margins. Above this the stalk expands into a campanulate sheath of elliptical outline and thin edges within which the tip of the stalk rises as a vertically perfoliate clavus, retractile within the sheath. The laminae upon the clavus are low, five to six in number, and borne upon each side of the flattened faces of the terminal clavus. The plates, the shortest below, are oblique, arising from a central ridge-like portion which projects above them in a blunt point. (Pl. 41, figs. 4, 5, 6, alcoholic specimen.) In preserved material the clavus may be much contracted and inconspicuous. This condition undoubtedly led to Heath's error (1917, p. 138) in failing to recognize its presence.

*Dorso-lateral papillae* or cerata paired, five to six on either side in a single series along the rounded dorso-lateral margin of the back, not otherwise accented, the first pair opposite, the remaining ones alternating in position on right and left sides, overlapping each other successively from front backward. These papillae are flattened, broadly ovate to rounded in outline, arising from a stout stalk, the margins smooth to the distal portion which bears two to six short sharp points. The dorsal face of each is slightly convex, its ventral face flattened. (Pl. 41, figs. 1, 2.)

The *cerata* range in length from 10 mm. for the longest, the second on the right, to 2 mm. for the shortest. Widths for the remainder vary from 8.5 mm. to 1 mm. The stalk insertion is 1 mm. in average width. When at rest, they are broad and nearly circular in outline; in swimming they become elongated. They are readily dehiscent and may be found in different stages of regeneration. The intricate network of the liver branches is clearly seen.

The *foot* is narrow and linear, anterior end rounded, sharply set off from the head above it; a lateral groove sets it off definitely from the rounded sides of the body



above, while posteriorly it extends slightly beyond the last dorsal cerata as a short bluntly pointed tail.

*Color* in life everywhere translucent pale indian yellow, dotted irregularly with very minute bluish-white spots. Liver branches light green or brown when seen by transmitted light. The light spots on the sides of the body appear to be at the ends of delicate branching tubes from within.

*Reproductive openings* close together on right side below and in front of the base of the first dorso-lateral ceras.

Opening of the penis on a low, rounded, smooth papilla directed obliquely backward. Just behind and below is a crescentic opening leading into a roomy atrium, the upper part of which is continued into the vagina, the lower portion into the cavity of the adnexed glands.

*Anal opening* on a small constricted papilla on right side between and slightly below the bases of the first and second cerata. Immediately above it is the minute renal pore.

*Dimensions* of specimen taken on January 3, 1902, at Third Beach, Pacific Grove, on floating *Postelsia*: total length 37 mm., mid-body width 7 mm., length of head when extended 10 mm., its width 17 mm., length of first ceras 13 mm., its width 7 mm. Number of outer, longer velar margin processes 52, the longest 3.0 mm. in length, the shorter ones 1.5 to 2.0 mm.

Height of rhinophore 5 mm., maximum width of its lateral expansion 3.5 mm., diameter of base of rhinophore stalk 1.75 mm., diameter of its calyx 2.0 mm., height of protruded club and its tip 1.0 mm.

*Dimensions*, alcoholic specimens. E. F. Ricketts, specimen taken in Gulf of California; length 19 mm., height 7.4 mm., width 6 mm., ceras length 11.7 mm., width 9.4 mm. Willis H. Rich, one large specimen taken at Afognak Island, Alaska; length of foot 69.5 mm., width of foot 33.0 mm., height of body 13.9 mm., diameter cowl 42.3 mm., length outer cirri 17.3 mm.

*Distribution.* The known range is from Kodiak Island, Alaska, south to the Gulf of California; the greatest abundance apparently being in the British Columbia region.

#### EXTENDED ANATOMICAL DESCRIPTION.

*Alimentary system* (pl. 54). Mouth elongate elliptical, 5.4 mm. long by 1.4 mm. maximum width. The lip margin is indicated by a narrow irregular marginal line bounding the entrance.

Mandibles and radula entirely absent, the pharyngeal bulb being reduced to a tube leading from the mouth opening to the oesophagus with no visible demarcation.

The opening leads into a roomy, compressed, arched cavity 2.4 mm. in maximum height, the posterior end of which passes into the oesophagus, wide at first, then



tapering down to a minimum diameter of 0.8 mm., dilating gradually into the stomach with no sharp boundary indicating the transition.

The nerve ring is not borne at the narrowest part, but well back where it reaches a diameter of 1.9 mm. The ring appears to be closely attached to the wall of the oesophagus and is enveloped by a close web of loose connective tissue. The length of the oesophagus from the posterior end of the mouth to just behind the nerve collar is 4.0 mm.

*Salivary glands.* (Pl. 54, fig. 8.) Lateral to the oesophagus and pharyngeal tube on either side close in front of the pedal and buccal commissures, is a small, somewhat lobular mass of gland cells. The cells contain a granular secretion and are grouped in short alveoli around short ductules which lead into the pharyngeal tube by a short duct on either side. These form the discrete salivary glands joined to the tube by abundant connective tissue, but forming distinctly separate organs and not inclosed in its wall as stated by Agersborg. Close behind them are the buccal ganglia. They evidently were not seen by Heath (1917) or Agersborg (1923). The latter described as salivary glands, numerous, simple or slightly branched tubular glands in the submucous layer of the oral tube. These undoubtedly correspond to the oral tube glands common to opisthobranchs and are quite distinct from the salivary glands proper.

Behind the nerve ring the *oesophagus stomach* swells to a diameter of 4.5 mm., nearly pyriform in outline as distended by ingested food material. On either side, posteriorly, it gives off a diverticulum which receives the liver branches, two on the left, and one on the right, and continues rapidly into a conical posterior or *pyloric* portion, which leads into the intestine. The pyloric wall shows faintly a circular zone of muscle fibers and probably contains the circle of masticatory plates.

At the end of the pyloric division laterally and ventrally is borne a saccular pyloric diverticulum beyond which the intestine passes in a simple curve back and to the right to the anus.

The intestinal wall bears a longitudinal typhlosole fold and numerous much smaller ones throughout its extent.

The total length of the stomach from nerve ring to beginning of the intestine is 7.4 mm. Width of pyloric girdle 1.5 mm. Length of intestine 0.8 mm. Maximum diameter of intestine 1.0 mm.

The anatomy of *Chioraera* has been discussed fragmentarily by Bergh (1904), and more extensively by Heath (1917), and by Agersborg (1923), the latter describing some notable differences in its organization from that of other nudibranchs. His results have been questioned by Odhner (1936).

In connection with other studies upon California nudibranchs I have had occasion to dissect specimens from Monterey Bay, Puget Sound, and Alaska. My results upon the reproductive system differ in so many important respects from those of Agersborg that they seem to justify separate publication.

*Reproductive system.* A general view of the reproductive system is represented in plate 54, figure 1, the parts being displaced only sufficiently to make clear their relations.

The ovotestis (*ov. t.*) fills the posterior part of the body almost completely. It is made up of a great number of spheroidal lobules, usually about 2 mm. in diameter, mostly simple but occasionally fused by twos or threes. Each lobule is made up of a central portion containing spermatozoa in various stages of development; peripheral to this are crowded alveoli containing developing ova.

The slender hermaphroditic duct is formed by branches converging from each lobe of the ovotestis. Close to the anterior border of the ovotestis region it dilates into the closely convoluted hermaphroditic ampulla, a thin-walled cylindrical sac 0.5 mm. in diameter, which is looped against the hinder face of the finely lobulated (grape-like) prostate gland, the two forming an ellipsoidal mass about 2.5 mm. long by 2.0 mm. in diameter. Upon its mid-upper face the ampulla curves inward, narrows suddenly, and gives off a slender branch, the oviduct, and continues as the spermatic duct or vas deferens which at once receives laterally short ducts from the lobules of the prostate gland.

Each of these ducts ramifies at once in all directions, each subdivision expanding into a dilated terminal lobule of the gland.

The first of these, the *oviduct*, 0.3 mm. in diameter, is a short, slender, closely coiled conduit, soon passing abruptly into a wider segment, the uterus, its proximal end forming a caecum-like dilatation into the side of which the oviduct enters. (Pl. 54, figs. 1, 2.) The lumen courses at one side of the axis and receives laterally a series of closely set, short, sac-like diverticula (pl. 54, fig. 2 at *a*), their narrowed openings directed forward. The first of these have simple smooth linings of low, ciliated, columnar cells, but soon their walls become thrown into secondary folds (fig. 3) and the diverticula open by wider apertures into the main lumen, now more central, and presenting numerous longitudinal folds. (Pl. 54, fig. 1 at *b*.) Distally the evaginations disappear and the *uterus* passes gradually into the muscular *vaginal* duct, the lining of which bears numerous, low, longitudinal ridges. Near its distal end, 5 mm. from the external opening (diameter 1.2 mm. at that point), it receives the short duct of a blind ovoid sac 5.3 mm. in length and 1.9 mm. in width, the receptaculum seminis, or spermatotheca. (Pl. 54, fig. 1, *sph.*) Near the external opening of the vaginal duct it unites with the broad outlet duct of the nidamental-albumen gland complex, the common external opening of the two being close behind the male orifice near the anterior end of the right side of the animal.

The *vas deferens*, upon separating from the *oviduct*, at once enters the prostate gland, a somewhat spheroidal mass of short closely set alveolar tubules. Its proximal face is overlaid by the convolutions of the hermaphroditic ampulla, from which, however, it may be readily separated, so that its relations are easily seen. The external surface of the *prostate gland* presents a mulberry-like appearance, produced by the distal ends of the simple or slightly branched alveoli, which are radially arranged. (Pl. 54, fig. 9.) The wall of each alveolus is made up of a columnar glandular epithelium rest-

ing upon a thin peripheral layer of connective tissue. Each alveolus leads into a short duct which unites centrally with other similar ones to form a small number of excretory ducts, which open close together into the lumen of the centrally placed *vas deferens*. The latter duct emerges from the prostate gland as a slender convoluted tubule with a thick muscular wall, and passes in a sinuous course, 0.6 mm. diameter, to the proximal end of the *preputium*.

The bundles of fibers from the retractor muscle of the penis pass backward close to the hermaphroditic duct and diverge into the connective tissue between the lobules. Possibly these may have been mistaken by Agersborg for vasa efferentia as indicated in his figure 81 of plate 37. The muscle fibers join bands from the body wall, interlacing in all directions through the pseudocoelom.

The *male intromittent* organ consists of a long, cylindrical, sac-like, thin-walled *preputium*, its wall containing conspicuous circular muscle bands, within which the equally long *flagelliform gland penis* is contained. It arises from the dilated proximal end of the preputium as a nearly cylindrical muscular organ, 0.8 mm. in diameter, and pursues a sinuous course. It tapers slightly for a short distance to a diameter of 0.6 mm., then flattens into a band-like structure with smooth contours which gradually narrows to 1.2 mm. diameter, and rapidly tapers into a slightly blunted tip. No trace of an armature of any kind is present.

The glans freed from the preputium in a large specimen about 70 mm. long, had these measurements: basal portion of glans 4.5 mm. long by 1.7 mm. wide in the cylindrical portion. The flattened ribbon-like portion irregularly twisted, 15.1 mm., giving a total length of 19.6 mm. as nearly as can be determined in its coiled and looped condition (*gls. p.*, pl. 54, fig. 1).

In fixed material the flattened part of the glans is somewhat twisted spirally, and also more or less irregularly kinked and bent. The margins of the glans are somewhat thickened and rounded, the wider faces between them are thus slightly convex. The *vas deferens* enters the *glans* at its base and its lumen pursues a spiral course, becoming straight only in the outer half of its length, and opening at the tip of the glans.

The description of the reproductive organs of *C. dalli* as given by Heath (1917) is substantially the same as that found here for *C. leonina*, and equally contradictory of Agersborg's account.

The description of Agersborg (1923) and his figures, especially figure 81 of plate 37, differ markedly from the above. His account contains numerous typographic and other errors, so that his meaning is not always clear. He described and figured two separate ducts, an oviduct and a spermatic duct, from each lobule of the hermaphroditic gland, instead of a single hermaphroditic duct as I have found. These two ducts are said to pursue independent courses. His spermatic duct passes straight forward and enlarges into what he terms the ampulla of the penis, "quadroluminate" at first; "anteriorly these lumina converge into three, then two and finally into one, which becomes the seminal tube of the penis." "From the ampulla the male duct passes anteriorly as a large organ of fibrous tissue. It is surrounded by a fibrous sheath of its own." Farther

on something designated as the "seminal vesicle" is spoken of, the penis being an extension of this. A transparent preparation, cleared after acid carmine staining, readily shows the actual relations of these parts. The "ampulla" is merely the proximal end of the preputium and its contained glans, the sinuous course of the lumen accounting for the varying number of lumina being seen in sections. The "fibrous sheath" is the preputium of molluscan anatomy. The "seminal vesicle" is simply the more distal cylindrical portion of the glans before it flattens.

The "oviduct" of Agersborg, then, is without doubt the actual hermaphroditic duct; what the "male genital duct" may be is not so clear. From the region of the basal end of the preputium a branch of the aorta passes backward close to the hermaphroditic duct and sends branches to each lobule of the ovotestis. This blood vessel may be what Agersborg has misinterpreted as a separate male duct. The retractor muscle of the penis may possibly be involved, for he neither mentions nor figures it, and its position closely resembles what he shows as extending backward from his "ampulla of the penis."

Again Agersborg states "the so-called prostate gland is a much coiled portion of the oviduct, consisting of two kinds of coils, a large and a small coil system coiled upon itself." Here evidently two distinct organs are confused. The large coils are those of the hermaphroditic ampulla, a constant structure in all nudibranchs, the small coils are the tubulo-alveolar lobules of the actual prostate gland, and between the two is the point of branching of the hermaphroditic duct into the oviduct and the vas deferens which he evidently overlooked entirely. The former has no connection with the prostate gland, but passes to the uterus, while the real vas deferens receives the ducts of the prostate gland, actually forming his "biluminate ampullo-prostate duct," and passing to the proximal end of the penis, enters it in its median basal face. Its "biluminate" character is an illusion owing to erroneous interpretation of sections. The prostate gland is not a part of the female duct, a truly weird relation, but opens into the vas deferens as is usual in all those nudibranchs in which the gland occurs.

If my observations and interpretations are correct, the whole plan of the arrangement of the reproductive ducts in *Chioraera*, so far from representing an "entirely new Type IV" of the molluscan genital ducts, is simply Type III of Lang's Lehrbuch, the diallic form characteristic of the Aeolidiacea in general. Incidentally, even if the condition as described by Agersborg did exist in *Chioraera*, which I cannot for a moment admit, to term it Type IV would be a misnomer, since the second edition of the Lang-Hescheler Lehrbuch (1900) lists four types instead of three, as in the earlier edition of Lang (1894) referred to by Agersborg, the fourth being the familiar triaulic type of the Doridacea. Lang's suggestive comparison of the multiform patterns of the molluscan reproductive organs has proved very valuable and it should not become confused by unfounded additions.

*Central nervous system.* (Pl. 54, figs. 6, 7, 8.) The cerebro-pleural ganglia have a somewhat irregular surface, formed in part by small lobules and in part by bulgings of very large nerve cells. The anterior margin is broadest, the median face

irregularly lobulated, the lateral border slightly concave, the posterior border simply rounded. They are in close contact in the median plane and fused with the pleural.

The pedal ganglia are large, nearly spherical; the cerebro-pedal and pleuro-pedal connectives are very short. (Pl. 54, fig. 6, *p.g.*, *c.p.c.*)

The small buccal ganglia lie close behind the salivary glands and at the same level, against the oesophagus. (Pl. 54, fig. 7.)

Plate 41, figure 4, shows clearly the rhinophore ganglion at the base of the clavus with branches innervating this organ.

*Connectives.* Close behind the salivary glands, as seen in ventral and side views, are the narrow but distinct bands of the pedal and parapedal commissures, and in front of them the more delicate buccal connective which is exceptionally long in this species. It unites the small buccal with the cerebral ganglion. These, and the pedal commissures, pass almost directly downward, the dorsal ganglia concealing them when viewed from above.

*Nerves.* From the small buccal ganglion on either side, a nerve passes forward into the pharyngeal bulb, another passes backward and ramifies to the stomach.

The central nervous system presents generally the characters described by Heath and the distribution of the nerves is substantially as given by him (1917, pl. 13, fig. 110) except no anastomoses with the parapedal commissures nor a nerve from the pleural ganglion can be found.

Agersborg gives practically nothing in any of his papers concerning the central nervous system, the eye, or the otocyst.

Heath (1917) failed to recognize the eyes, his description of the otocyst applies exactly to the eye. The lens of the eye is 0.1 mm. in diameter, nearly spherical, yellowish, the optic cup carrying it is deeply pigmented with black in the proximal part. The optic nerve arises from the median anterior face of the cerebral ganglion, is very short, and must be studied in sections. The otocyst lies behind, below the eyes, close above the contact of the cerebro-pleural and pedal ganglia surfaces in front of the cerebro-pedal connective. The spherical capsule, 0.012 mm. in diameter, is lined with cuboidal cells and contains a large number of otoliths, 0.009 mm. long, 0.006 mm. wide. (Pl. 54, figs. 6, 7.)

The careful description and excellent figures given by Heath for the central nervous system of *Chioraera dalli* agree also with what I have found for *Chioraera leonina* and provide further evidence of the identity of the two forms.

## Family DOTONIDAE

### Genus Doto Oken

*Doto* OKEN. 1815. Lehrb. der Naturgesch. III, Zool., vol. 1, p. 278. Type by subsequent designation *Doris maculata* Montagu, 1804. GRAY. 1847. Proc. Zool. Soc. London, p. 165. Not *Doto* "Oken" 1807, Goettingen, gelehrte Anz., 1807, pt. 2, p. 1168, which is not a scientific description, and by an unknown writer, not Oken.



*Idulia* LEACH, 1852. Synopsis Moll. Great Britain, p. 25. Type by monotypy, *Doris maculata* Montagu, 1804 (= *Doris coronata* Gmelin, 1791, Linn. Syst. Nat., Ed. 13, 1, pt. 6, p. 3105).

*Dotona* IREDALE, 1918. Proc. Malacol. Soc. London, vol. 13, p. 30. Type *Melibaea fragilis* Forbes, 1838.

*History of the genus.* The genus *Doto* was established by Oken in 1815 with *Doris maculata* as the type. Iredale and O'Donoghue would substitute *Idulia* Leach, 1852, as the generic name, arguing that *Doto* is invalidated by its previous appearance in 1807. Mme. Pruvot-Fol (1931) has clearly shown, however, that the name was not used in a scientific description, was by an anonymous writer, and does not prevent its use by Oken later. Odhner (1934, 1936) agrees with this interpretation, and the present writer is in full accord.

The type species was designated by Gray (1847, p. 165) as *Doris maculata* Montagu, 1804, the first example listed by Oken in vol. 1, p. 278 of his Lehrbuch, which name is antedated by *Doris coronata* Gmelin, 1791 (Syst. Nat., 13th Ed. by Gmelin. T. I, pars. 6, p. 3105). *Idulia* Leach, *Dotona* Iredale, and *Bornellopsis* O'Donoghue are evidently synonyms.

A large number of species have been described or assigned to the genus. All seem to show strong similarity and the slight differences refer mainly to coloration which fortunately is shown to a great extent in preserved specimens. The radula teeth and the mandibles show very slight differences, and the former seem to be highly variable. All require further study to determine satisfactorily the limits of developmental stages and of adult variability.

In the meantime, the synopsis of species as worked out by Odhner (1936, pp. 1119-1121) is very useful.

Two eastern Pacific Coast species are here given, *Doto columbiana* O'Donoghue 1921, and the California species *Doto varians*, here first described.

### *Doto columbiana* O'Donoghue

*Doto columbiana* O'DONOGHUE, 1921. Trans. Roy. Can. Inst., Toronto, vol. 13, pt. 1, pp. 204-205, pl. 3 (9), fig. 33; 1926, *ibid.*, vol. 15, pt. 1, p. 235.

*Body* elongate, limaciform; cerata five pairs, clavate, dehiscent, globose, studded with 18 to 22 short, truncate, cone-like tubercles; oral veil narrow, bearing a few short papillae; rhinophores smooth, blunt, cylindrical rods, retractile into prominent, deep, cup-shaped sheaths with smooth margins; foot elongate, narrowing from nearly concave, blunt front end to pointed tail.

*Color* grayish white to pale grayish yellow over body and foot alike; on back and along sides scattered black pencillings, the raised cerata nodules edged with black.

*Mandibles* fairly thin and very pale, oval, smooth, covering the major part of the pharyngeal mass. Radula very pale and tiny, long and narrow, uniseriate with 86



to 96 rows of teeth, each tooth with horseshoe-shaped base, median cusp and three small lateral spines on or near apex of median cusp and two nearer its base.

*Penis* short, unarmed.

*Dimensions.* Large living specimen 14 mm. long by 2.75 mm. high by 2.25 mm. wide.

*Habitat.* Vancouver Island region in 12-20 fathoms. Three specimens recorded by O'Donoghue, no record of any other captures.

### *Doto varians* MacFarland, new species

Plate 42, figures 1-8; plate 44, figures 8-17; plate 48, figures 9-13

*Body* elongate, limaciform, highly arched in cross section, the foot narrower than the body, linear, scarcely set off from the sides, its anterior end rounded, tapering behind to a short blunt tip.

*Frontal veil* rounded, slightly expanded laterally, its surface entirely smooth, its margin entire.

*Rhinophores* erect, divergent, clavus slender, bluntly tapering, smooth, retractile within large, obliquely truncate, calyciform sheaths with smooth margins flaring forward. The clavi extend nearly one-half the full length of the rhinophore and are directed obliquely forward and outward; their tips keep up a peculiar jerking motion at close intervals during full activity of the animal.

*Cerata* large, club-shaped, inflated, arranged in a single series along the dorso-lateral margin of the body which is not otherwise delimited. Cerata arranged in five to eight pairs, each with a slender tapering stalk; maximum length 3 mm., readily dehiscent and capable of regeneration. Each ceras bears five or six circles of hemispherical tubercles into which ramifications of the liver project from the central axis; the nodules increase in size for two or three circles and then may decrease as the tip of the ceras is approached, the apex being a low rounded tubercle similar to the lateral ones. The tubercles are directed upward on the central axis and are slightly elongated into a ridge which dies away below, merging with the axis of the stalk. (Pl. 42, fig. 2.)

On the inner face of the larger of the cerata is borne a low, colorless, vertical ridge extending nearly to its summit, dying away below as the body is approached, and terminating above more or less abruptly. From the sides of this median plate, several small lateral branches may be given off extending obliquely upward, the whole containing vascular channels and forming a gill-like modification of the inner face of the ceras. (Pl. 42, figs. 5-8.) They are entirely free from branches of the liver with which the remainder of the ceras is crowded.

The ridges herein described for *Doto varians*, as stated, are to be regarded as a gill differentiation. Trinchese (1881) has figured similar structures in *Doto cornaliae* (pl. 61, fig. 1, e). Odhner (1936) has described such gill formation in *D. coronata*, *D.*

*fragilis*, and *D. pinnatifida*, and less distinctly in *D. japonica* and *D. apiculata*. In view of these facts, the formation of a new genus, *Bornellopsis*, by O'Donoghue (1929) for *B. kabretiana*, based upon gill structures such as these cannot be justified, and, as Odhner has rightly argued, *Bornellopsis* becomes another synonym for *Doto*.

*Anal opening* at the summit of a slender cylindrical papilla, flaring slightly at its top, just within the line of the bases of the right cerata and close to the second one. The anal papilla is about one-third the height of the adjacent cerata. (Pl. 44, fig. 14.)

*Renal opening* (nephroproct) close to, or within, the anal opening of the papilla. *Nephridial tube* 0.16 mm. long, 0.096 mm. wide. (Pl. 44, figs. 15. 16.)

*Genital openings* upon a rounded elevation on right anterior side, immediately below the base of the first ceras. In front is that of the penis, and behind, in a crescentic depression, is the *female vestibule* with the opening of the vagina above and the nidamental glands and oviduct below.

Plate 48 shows four radula teeth, two taken from a specimen of yellow coloring (figs. 10, 11), and two from a dark mottled specimen (figs. 12, 13).

*Mandibles*. (Pl. 48, fig. 9.) Yellow specimen. Mandibles are short, widely triangular in outline, very thin, colorless, slightly thickened in anterior region of the hinge. They cover the anterior end of the bulb only, no mandibular process or armature can be seen. Height, tip to tip, 0.32 mm.; length 0.64 mm.

*Radula* very small, the teeth uniseriate in 56 to 88 or more rows. The teeth are curved, horseshoe-shaped, the sides convex, the median posterior cusp depressed below a triangular denticle of equal size on either side close to the center cusp which is directed upward and backward. The two are not symmetrically placed; one or the other is nearer the cusp. Near the outer anterior margin is a group of three slightly smaller denticles with an occasional old one. (Pl. 48, figs. 10, 11.)

The base is narrow and curved. The teeth articulate closely by means of a rounded projection from the anterior inner end of each lateral basal portion, fitting into a depression on the posterior surface of the lateral base of its succeeding tooth.

In the dark variety the teeth are slightly smaller, but similar in shape, with three denticles on the posterior point of the cusp, the center one depressed. On the outer anterior margin there may occur a group of two on either side, or but one may be found. (Pl. 48, figs. 12, 13.)

*Color*. (Pl. 42, figs. 1-8.) Many specimens have been collected by the author from the tide pools of Monterey Bay over a period of years.

An effort has been made to isolate these into groups based largely upon coloration. Three distinct groups are recorded.

The integument is translucent. The general body color, to a large degree, is due to the color of the liver lobules and the viscera. The cerata coloring from the liver is

massed in the central axis. The superficial pigment occurs in varying amounts of sprinklings, spots, blotches, and lines, giving variation in the darker specimens.

A. The specimens of *lightest colorings* are in general white, pale shell pink to pale yellow. The liver lobules are a decided pink in some or pale brown in others; the viscera are brown. An encrusting of white covers the rounded ends of the tubercles; white sprinklings occur on the rhinophore clavus and sheath. (Pl. 42, fig. 7.) Pale varieties have slender cerata stalks, small tubercles.

B. The *yellow* specimens have a body color of this shade; the deep-yellow lobes of the ovotestis show through the body integument. The liver lobules filling the axis of the cerata are yellow to deep brown. The same encrustings of white occur as described for the light-colored specimens. (Pl. 42, figs. 3, 5, 6.)

C. Group of *dark-colored* specimens. The general ground color is gray, cream, pale yellow to orange; the ovotestis shows through the integument as an orange-yellow mass, its extent varying with the degree of sexual maturity of the individual. (Pl. 42, figs. 2, 4, 8.)

In the mid-dorsum are two irregular bands of dark brown which die away in the tail region but extend forward in front of the heart between the rhinophores and merge, or become indistinct, upon the dorsal surface of the veil.

These bands are not sharply defined throughout and may merge together in a mottled median area from which, as well as from the more clearly defined pair of bands, lateral extensions may pass outward and downward between adjacent cerata and join a vaguely defined longitudinal band below them on either side of the body. (Pl. 42, fig. 4.)

This lateral band may be continuous or may be replaced by a series of discontinuous blotches of dark brown of varying extent. The inner surfaces of the rhinophore sheaths are usually a very dark rich brown, and fine sprinklings may occur upon the cerata between the bases of the tubercles as well as on them.

The rhinophore clavus has numerous superficial white spots toward the tips and on the flaring edge of the sheath, with a few inside; white encrustation is found over the rounded ends of the tubercles of the cerata.

The superficial color is burnt sienna, umber, or very dark brown to black with an occasional green or blue spot to be found, all in varying amounts.

Intermediate forms between the light and dark varieties of coloration are rare, and a complete graduation has never been found.

*Dimensions.* Length up to 11.5 or 12 mm.; maximum height of body 1.6 mm.; maximum width of body 1.4 mm.; length of largest cerata about 4 mm.; maximum diameter of largest cerata one-third to one-half the length; height of whole rhinophore 3.2 mm.; height of its sheath about one-half total length. Length of tail 2.4 mm. The range in length of a number of specimens taken at one time: 7, 7.5, 9.5, 10, 11.5, 14 mm.

*Habitat.* In tide pools and upon kelp-bearing hydroids such as *Aglaophenia* and *Abietinaria*, matching in color that of the nudibranch. Common in the Monterey Bay area, at all times of the year, but more abundant during the summer months.

## EXTENDED ANATOMICAL DESCRIPTION.

*Glands.* The anterior foot margin and the lips of the oral openings are abundantly supplied with simple alveolar glands extending backward along the oral tube as far as the middle of the pharyngeal bulb. They are made up of pyriform follicles of a small number of secreting cells with small, deeply staining, basophile nuclei and finely granular acidophile cytoplasm. Between the columnar epithelium cells of the integument, each gland opens to the exterior, by a slender duct of varying length. These glands form a thick mass adjacent to the oral tube.

*Salivary glands.* Two pre-bulbar alveolar salivary glands are present, and are essentially identical with those described by Hecht (1896) for *Doto coronata* and *Doto pinnatifida*, and by Brygider (1914), more in detail, for *Doto coronata*. Their ducts are superimposed, open into the floor of the posterior end of the oral tube immediately in front of the pharyngeal bulb, and pass backward beneath the latter to its posterior end where each opens into a roomy sac lying to the left and lateral to the bulb and oesophagus. The two ducts are closely bound together by connective tissue in a common sheath. The uppermost slightly larger duct is somewhat flattened and longitudinally grooved on its ventral surface by the pressure of the lower cylindrical duct around the upper surface of which it fits. The lining cells are cuboidal, with very large deeply staining nuclei. Occasional muscle fibers and but little connective tissue surrounds each duct.

The terminal sacs of the glands are distended, but in part are thrown into irregular folds. Their epithelium is cuboidal, the size varying with different secretion stages, the nuclei large, spherical, and rich in chromatin granules, the granular cytoplasm agreeing in the main with the description of Brygider (1914).

Associated with these cells occur a number of truly gigantic ones, reaching a diameter of .150 mm. These giant cells are much larger than those described by Hecht (1896) and by Brygider for *Doto coronata* which are stated to range from 0.03 to 0.07 mm. in diameter. The structure agrees with their accounts; the cells are closely attached to the gland epithelium by a slender prolongation pushed in between the epithelial cells and reaching the gland lumen, the cell body lies outside of the wall as a knob-like protuberance. It is enveloped by a thin but distinct nucleated membrane or a muscular layer which is continuous with the tunica propria of the gland. The cytoplasm is finely and densely granular, the granules acidophile, the nucleus is very large, spherical, oval, crescentic, lobed, or even divided and is densely packed with fine chromatin granules.

These giant cells are found in close contact with the wall of the salivary sac and their connection by a slender process of cytoplasm with the lumen can usually be made out, especially in thin serial sections, though frequently it may be obscured by folds of the epithelial wall. They are found associated with the terminal sacs (alveoli) of either gland.

It is not impossible that some of these cells are entirely free from union with the salivary sacs (alveoli), but unquestionable cases of such have not been found. Occasionally a few of these giant cells may be found at the extreme anterior end of the

gland sacs and in close contact with the entrance of the ducts or even surrounding other united ducts.

*Reproductive system.* Yellow specimen used in the following description:

Figure 8 of plate 44 represents the anterior genital complex of *Doto*, the parts being displaced somewhat from their close union in order to bring out their relations with each other. Their proportionate sizes are maintained, the large albumen and mucous lobes of the nidamental glands being omitted. The dorsal wall of the preputium has been removed to show the conical glans penis within it. (Pl. 44, figs. 8 to 17 inclusive.)

The following abbreviations designate the respective parts of the system:

*h. d.* hermaphroditic duct from ovotestis

*h. a.* hermaphroditic ampulla

*d. h. d.* distal part of hermaphroditic duct

*ov. d.* oviduct

*spth.* spermatheca (receptaculum seminis)

*v.* vagina

*f. o. v.* external opening of female vestibule formed by union of openings of vagina and the nidamental glands

*pr.* prostate gland

*v. d.* vas deferens

*p.* preputium

*gl.* glans penis

The *preputium* is an elongated sac, .24 mm. diameter on the outside, .13 mm. inside, containing the conical glans penis which is .33 mm. long. This is covered with a low cuboidal epithelium, bluntly pointed at the tip and unarmed.

The *vas deferens* (pl. 44, fig. 8, *v. d.*) emerges from the base of the penis as a slender tube with muscular walls 0.09 mm. in diameter, its lumen lined with ciliated cuboidal epithelium. It doubles downward and outward below the preputium, loops toward the median plane, and thence dilates into the prostatic portion (pl. 44, fig. 8, *pr.*), a large pyriform segment lying behind the penis.

Its broader proximal end curves downward, narrows suddenly into a very short duct which joins the *hermaphroditic duct* at its bifurcation into the *oviduct* and the *vas deferens*.

The epithelium of the prostate is made up of large finely saccular cells with rounded free ends projecting unequally into the lumen. In places the lining of the prostate is thrown into low folds or papilla-like elevations. Their nuclei are relatively small, densely chromatic, and lie at various levels in the cells. (Pl. 44, fig. 13.)

Toward the outer end the prostate gland narrows continually, the lumen becomes small, and the above cells are replaced by high columnar ones with more acido-



phile staining qualities. The nuclei are dense and basal in position, surrounded by a narrow zone of slightly basophile cytoplasm. The bulk of the cell is filled with fine rounded granules, giving an acidophile reaction with eosin azure stain. Wedged in between the cells are slender supporting cells with a distally placed small nucleus close below the cell boundary. In one series, the acidophile cells seem to be giving off droplets of acidophile colloid which appear to aggregate together into a slender rod-like structure which may be traced through the remainder of the prostate and the vas deferens to the tip of the glans penis. (Pl. 44, figs. 11, 12, 13.)

*Female channel.* Behind the male opening lies the crescentic aperture of the female vestibulum, its concavity directed forward, its upper horn on a level with the male opening. From its upper portion the vagina diverges; from the lower and median portion the openings to the albumen and mucous glands arise.

The vagina is lined by longitudinally folded ciliated columnar epithelium, surrounded by a muscular wall. It passes inward behind the preputium, curves downward, and dilates into a roomy sac, tapering above, widening and curving to the left below.

Its wall, at first smooth, develops radial folds which extend farther inward toward the center, as the sac curves toward the left (fig. 9) and in an inner prolongation of a narrow duct, entering the sac at or near its widest portion. By this union the lower proximal end of the sac becomes divided into some six to nine compartments, separate below but freely communicating above with the general lumen and with each other. In cross section a wheel-like appearance is thus formed, as is shown in figure 10 of plate 44, the axis or hub being formed by the invaginated duct which thus communicates freely with the lumen of the sac and that of the radial compartments, each being a tubulo-alveolar evagination from the wall of the vaginal duct and arranged in a circle around it, the whole being lined by a cuboidal epithelium bearing long cilia. These lateral alveoli are filled with spermatozoa in some cases and the whole is to be interpreted as a modified receptaculum seminis.

The oviduct emerges very narrow and dilates at once into a relatively wide channel which passes backward and then doubles back upon itself forming a U-shaped loop, the second limb being parallel to the first and of equal diameter and extent. At the anterior end of the second portion it dilates slightly and is telescoped, as it were, by the end of the tube opening into it. This is the distal end of the hermaphroditic duct just after it gives off the vas deferens. (Pl. 44, fig. 10.)

Odhner (1922) described and figured a long-shafted receptaculum seminis opening into the vestibulum in *Doto coronata*. No trace of an organ of this form is present in *Doto varians* here described, its place being taken by the blind pockets differentiated at the proximal end of the female vestibulum or vagina as indicated.

The hermaphroditic ampulla is large, somewhat reniform in outline, and receives at its posterior end the hermaphroditic duct formed by the union of many branches from the lobules of the ovotestis.

The ovotestis forms a mass of large follicles above the posterior liver duct and extends forward above it.



SUMMARY OF CHARACTERISTICS OF *DOTO* SPECIMENS

*Cerata.* The number varies according to the size of the specimen; frequently some have dropped off or been injured. For the range in different individuals, five to nine pairs have been recorded. The general form is club-shaped, somewhat elongated, arising from a slender base; the stalk expands to a diameter one-half its length, depending upon the degree of inflation, becoming rounded and narrowed at the top. The cerata, with their inflated tubercles, are quite large in comparison with the size of the body.

*Tubercles.* These are borne in circles about the stalk of the cerata, often not definitely defined and occasionally upon a slightly elevated ridge; four to six circles are found with a varying number of three, six, or eight in the circle. These are in general rounded and knob-like, on some individuals slightly pointed, elongated and small, with a gradual gradation from the base to the center where the largest are found, with a large terminal one at the tip.

*Rhinophores.* These are shorter than the longest cerata. In general the sheath is calciform, flaring to a greater or less degree, inclined forward, sometimes notched on the anterior or posterior margin. The edges are thin or thick, fitting about the clavus which is fully as long as the entire sheath or longer, perfectly smooth, with flecks of white on the surface.

These special characteristics of the sheath do not apply definitely to any one of the color varieties.

The *gill-like* differentiation on the inner face of the cerata is found on all specimens of all coloring, varying in height and form. (Pl. 42, figs. 5-8.)

No significant internal anatomical details, justifying the recognition of the varieties as separate species, have as yet been found.

The only species of *Doto* previously described from the Pacific coast of North America is *Doto columbiana* O'Donoghue, 1921. This appears to differ from the present species in having but five pairs of cerata, the presence of a few short papillae upon the velum (margin? or dorsal surface?), the rhinophore clavus is slightly roughened, and the color is grayish white or pale grayish yellow with scattered black pencillings on the back and sides, and an edging of black surrounding the tubercles of the cerata. Scanty structural details and no figures are given in O'Donoghue's account.

## Superfamily AEOLIDIACEA

## Family DIRONIDAE

Genus *Dirona* MacFarland

*Dirona* MacFarland in Cockerell and Eliot, 1905. Notes on a Collection of California Nudibranchs. Journ. Malacol., vol. 12, no. 3, p. 45. Genotype, *Dirona picta* MacFarland. MacFarland, 1912. The Nudibranch Family Dironidae. Zool. Jahrbücher, supplement 15, 1, pp. 516-517. O'DONOGHUE, 1921. Nudibranchiate Mollusca of the Vancouver Island region. Trans. Roy. Can. Institute, Toronto, vol. 13, pt. 1, p. 181.

*Generic diagnosis.* Body broad, sub-depressed; head bearing a broad, thin veil with thin, smooth, undulating margin, in width equal to or wider than the foot; rhinophores perfoliate, without sheaths; dorsal papillae large, inflated, non-caducous, arranged irregularly along the margin of the dorsum in a closely set series extending nearly to the median line anteriorly in front of the rhinophores, the papillae of varying size, spindle-shaped, the largest usually innermost with smaller ones external to their bases, cnidosacs absent.

*Foot* broad, rounded in front, tapering behind to a short tail.

*Liver* lobulated, with ramifications to the dorsal papillae.

*Anus* at the summit of a conspicuous papilla, far back on the right side, just below the posterior dorsal papillae.

*Lip disk* covered with thick-set, hair-like, cuticular processes. Mandibles massive, the masticatory surface broad and smooth, formed by a shield-like expansion which is reflected over the anterior margin of the mandible.

*Radula* narrow, its formula (2·1·2), the median tooth small, the laterals widely separate from it. First lateral depressed, of moderate size, its blunt cusp denticulate on its inner basal surface, the second lateral large, compressed, simply hamate. Penis armed or not.

The genus *Dirona*, based upon *Dirona picta*, was described by me in manuscript in 1893 from specimens taken at Pacific Grove, California. Publication, however, was deferred pending the completion of further studies upon it and other nudibranchs. Full details of it were supplied to Professor T. D. A. Cockerell upon his later inquiry concerning a problematical specimen which he had collected at San Pedro, and these, together with one of my drawings of the living animal, were incorporated by Sir Charles Eliot in "Notes on a Collection of California Nudibranchs" in the Journal of Malacology, 1905, vol. 12, no. 3, p. 45, by Cockerell and Eliot, the new genus and species being very properly accredited to me. In 1912 my paper "The Nudibranch Family Dironidae" appeared in the Spengel Festschrift, in which the validity of the genus with two species was clearly established, and the new family Dironidae was proposed for their reception.

#### *Dirona picta* MACFARLAND

Plate 56, figures 5-7; plate 63, figures 1-8; plate 64, figures 1-3

*Dirona picta* MACFARLAND in Cockerell and Eliot, 1905. Journ. Malacol., vol. 12, no. 3, pp. 46-48, pl. 7, figs. 6-11. MACFARLAND, 1912. The Nudibranch Family Dironidae. Zool. Jahrbücher, supplement 15, 1, pp. 517, 518, 520-533, pl. 30, fig. 1; pl. 31, figs. 1-10; pl. 32, figs. 20, 22-24. O'DONOGHUE, 1927. Notes on a Collection of Nudibranchs from Laguna Beach, California. Journ. Entomol. and Zool., Pomona College, vol. 19, pp. 101, 102, pl. 3, figs. 60-63.

*Body form* stout, surface smooth, somewhat limaciform, abruptly rounded in front, posteriorly tapering to the tip of a rather short tail. Dorsum slightly rounded, sloping rapidly behind the heart region, less so in front. Head broad, squarish, its margin expanded into a broad undulating veil. Foot elongate, bluntly rounded in front, edge entire, tapering posteriorly to the short tail, which is about one-third to one-fourth of the body length.

*Rhinophores* without sheaths, directed forward and outward, clavate, the clavus irregularly perfoliate, one-third to one-half the length of the whole organ.

*Dorsal papillae* lanceolate, inflated, slightly flattened antero-posteriorly with pointed apices, non-caducous or but slightly so, arranged in closely set irregular series along each side of the dorsum, converging in front of the rhinophores toward the median line, but not meeting, thus leaving a narrow, median area free from papillae, the rows meeting behind above the tail. Inner surfaces of the papillae tuberculate, the elevations often being confluent into a low, median, longitudinal ridge with short, irregular branches, small tubercles on edges of the outer surface. The largest papillae may reach one-third to one-half the length of the animal, and are innermost in position, the shorter ones being arranged externally to them. Dorsal papillae do not contain branches of the liver, and are destitute of cnidosacs.

*Reproductive openings* two, inconspicuous, situated on upper, anterior part of the right side close below the dorso-lateral papillae, one-third posterior of the head margin.

*Renal opening* close to the outermost papillae a short distance, 5 mm., behind the reproductive openings, and widely separated from the anal opening, which is situated upon the summit of a conical papilla far back on the right side, in the line of the outermost posterior papillae.

The general average *color* of the body is a light yellow ochre to burnt umber. Individuals vary in depth of color because of the many spots and blotches over the surface. The lighter specimens have small cream and pink spots and points over the entire surface almost as an encrusting. The pale-red spot on the outer side of the cerata, one-third distant from the base, is a constant mark. The darker specimens are covered with dark-brown, dull-green, and yellow spots, all varying in size and shape and depth of color. Rhinophore plates a pale shade of the light body color. In the mid-dorsal and lateral region, the dark olive-green liver shows conspicuously through the integument.

*Mouth* a vertical slit, inner labial disk with fine, closely set, radial folds covered by a thick cuticular investment of long, slender, hair-like processes. *Mandibles* strong and massive, the hinge region and grinding surface deep reddish amber, the wing paler. Lateral expansion thick, somewhat triangular, its dorsal border straight, the posterior and ventral borders rounded, the upper portion thickened, its outer surface convex, the inner surface convex above, somewhat concave below. Upon the anterior inner surface

is borne a shield-shaped plate, reflexed outwardly in front and forming the broad, smooth or slightly roughened masticatory surface. The mandibles are united together above by a strong ligament in front, and immediately behind it by a chitinous band, triangular in cross section. (Pl. 63, figs. 6, 7, 8.)

*Radula* formula 32-35 (2·1·2). Rachidian tooth small, at the bottom of a deep median groove, widely separated from the laterals, its base strong, squarish, notched in front, rounded behind, bearing a single, median spine directed obliquely upward and backward.

First lateral larger, strongly depressed, its base elongate, linear, with rounded ends, bearing a single strong spine which is slightly curved and bears on its inner face, near the base, a series of from six to seven denticles, at times extending well up along the side of the spine. Outer lateral large, hamate, strongly compressed, its base long and curved, the tip of the hook blunt. The tooth is placed very obliquely on the upper margin of the radular groove, and is attached along the lower side of the base, instead of at its bottom. (Pl. 63, figs. 1-5.)

*Glans penis* short, conical; spermatheca very small; oviduct long and wide. (Pl. 64, fig. 2.)

*Dimensions.* Monterey Bay, living specimen (pl. 56, figs. 5-7). Length 40 mm., width 6 mm., height 5 mm. Length of tail from tip to hindermost cerata 12 mm.; veil 8 mm. in width. Largest ceras 10 mm. long by 3 mm. wide; smallest ceras 1 mm. long; rhinophore stalk 6 mm. high, clavus 3 mm. Average alcoholic specimens range from 13 to 20 mm. long, 4 to 8 mm. wide, 6 to 8 mm. high.

*Habitat.* Southern shore of Monterey Bay, California, and adjacent coastline, abundant during the summer months in littoral zone on rocky places, crawling on the brown kelp, or in quiet pools, often floating at the surface, foot uppermost. Taken as far north as Crescent City and as far south as La Jolla; Newport Bay (MacFarland); San Pedro (Cockerell); Laguna Beach (Hilton); San Diego (Johnson and Snook).

### *Dirona albolineata* MACFARLAND

Plate 30, figure 13; plate 56, figures 1-4; plate 63, figures 9-12;  
plate 64, figures 4-10

*Dirona albolineata* MACFARLAND, 1912. The Nudibranch Family Dironidae. Zool. Jahrb., supplement 15, 1, (Festschrift für Spengel); pp. 518-533, pl. 30, fig. 2; pl. 31, figs. 11-19; pl. 32, fig. 21. O'DONOGHUE, 1921. Nudibranchs of the Vancouver region. Trans. Roy. Can. Institute, Toronto, vol. 13, pt. 1, pp. 181-183, pl. 2 (8), figs. 23, 24. O'DONOGHUE, 1927. Notes on a Collection of Nudibranchs from Laguna Beach, California. Journ. Entomol. and Zool., Pomona College, vol. 19, pp. 102, 103, pl. 3, figs. 64-67. BABA, 1935. The Fauna of Akkeshi Bay, I. Opisthobranchia. Journ. Faculty of Science Hokkaido Imperial University, series 4, Zool., vol. 4, no. 3, pp. 120-121, pl. 7, figs. 11-16; pl. 8, figs. 1-2.

*Body* broad, somewhat limaciform, everywhere smooth, tapering from the bluntly rounded head to the tip of the short, pointed tail. Head broad, squarish, bearing a very broad, gently undulating veil, no labial tentacles. Foot elongate, broad and rounded in front, tapering posteriorly, its slightly thickened anterior margin smooth, undivided. A distinct groove is between it and the ventral head surface, on the posterior veil margin.

*Rhinophores* without sheaths, directed forward and outward, the clavus conical, deeply and regularly perfoliate, about one-half the length of the whole rhinophore.

*Dorsal papillae* lanceolate, pointed at the tip, inflated, entirely smooth, somewhat flattened antero-posteriorly, arranged in closely set, irregular series along the dorso-lateral margins of the body. Largest innermost ones reaching frequently one-fourth to one-half the length of the body. smaller ones, 1 mm. long, are external to these in closely set, irregular series. Papillae continued forward in front of the rhinophores toward the median line of the body, but do not meet. Posteriorly the dorsal papillae meet above the tail. No cnidosacs present and no branches of the liver extend into the papillae. In preserved material the body frequently becomes more prismatic in form, the head and veil strongly contracted and the dorsum highly arched, while the dorsal papillae become much shorter and thicker.

*Reproductive openings* two, inconspicuous, situated on the right side close to the junction of the anterior and middle third of the body below the dorso-lateral rows of papillae. The anterior and upper opening is that of the glans penis. Close behind and below is the vaginal opening at the top of a crescentic groove nearly vertical in position. The groove from the opening continues downward and deepens into the nidamental gland. The oviduct opens at the lower limb of this groove. The posterior border is but slightly elevated above the general level of the side, the anterior border is more prominent and is prolonged as a wide triangular flap, the top of which overlaps the lower opening slightly. It is also elevated above the surface of the body wall into which it dies away below the opening of the preputium and the projecting glans. (Pl. 64, fig. 9.)

*Renal opening* a minute pore close below the rows of papillae a short distance, 5 mm., behind the reproductive openings.

*Anal opening* far back on the right side at the summit of a low cylindrical papilla, in the line of the outermost papillae near the posterior end of the body.

*Mouth* elongated oval, lips thick, rounded in toward the mandible.

*Mandibles* strong and massive, similar in form to those of *Dirona picta*, the hinge region and grinding surface dark amber, the wing lighter. Dorsal margin nearly straight, the ventral and hinder margins curved. Masticatory portion modified into a large, oval surface overlapping the antero-ventral margins of the mandible, its surface smooth. (Pl. 56, figs. 2, 3.)

*Radula* formula 29-32 (2·1·2). Median tooth quite small, at the bottom of the deep median groove of the radula, its base rounded in front, squarish behind, in lateral



view triangular, its upper surface prolonged into a straight spine which is often finely grooved on the upper surface. First lateral tooth depressed, nearly horizontal, its base elongated, nearly linear, the ends rounded, above prolonged into a stout, slightly curved spine or hook, which rises but slightly above the plane of the upper surface of the base. Upon the lower inner margin of this hook is borne a series of two to four short pointed denticles. Second lateral large, hamate, very much compressed, borne obliquely upon the margin of the radula groove, the tooth strongly inclined, its base being attached to the membrane on its inner lateral surface. Base long and slender and much curved to conform to the surface to which it is attached. Hook simple, strongly curved, the tip blunt.

*Glans penis* elongate, with thickly set papillae bearing thorn-like points; spermatheca large; oviduct short and slender. (Pl. 64, figs. 4, 5.)

*Color* everywhere a beautiful translucent gray save for a narrow band of pure white edging the veil above and below, the lateral margins of the dorsal papillae, and the median crest of the tail, a similar band of white passing from the inner lower margin of the clavus of each rhinophore down the inner face of the rhinophore stalk and uniting in a transverse line across the head. These lines are a narrow encrusting of dead white on the surface. Rhinophore stalk a clear white, plates delicate yellow ochre. In large individuals the body and papillae are occasionally flecked with a few, minute, pure-white spots, and a pale-amber tinge, quite diffuse, may be seen in the body and more pronounced in the dorsal papillae. The stomach, intestine, and liver are frequently bluish-black in color and the lobules of the mature ovotestis become a conspicuous pink hue, all showing through the integument. Along the upper right side, just below the bases of the dorsal papillae, and extending from immediately behind and above the reproductive openings to the posterior end of the papilla rows, is a broad whitish band, conspicuous in alcoholic material owing to a strongly developed glandular zone.

*Dimensions.* Living specimens from Monterey Bay averaged in length 32 to 42 mm., width 7 mm., height 8 mm. One specimen, 38 mm. in length, had a veil 16 mm. in width, rhinophore 10 mm. high; large ceras 14 mm. long. Larger specimens have been taken from localities farther north, 14 being taken by the author from Crescent City pools, all exceeding 38 mm. in length; one, 66.5 mm. long with a tail length of 19.6 mm. behind the papillae. C. H. O'Donoghue recorded specimens from the Nanaimo region 72 to 109 mm. long, 14 to 32 mm. wide, 15 to 30 mm. high. Large alcoholic specimens measure in length 42 to 56.5 mm., 11 to 14 mm. in width, and 13 to 22 mm. in height.

*Habitat.* Southern shore, Monterey Bay, extreme low tide, rare. Reported from Laguna Beach, California, northward to Crescent City, California, more common, August 4, 1940, MacFarland; Friday Harbor, Washington by Guberlet, 1940, two specimens; Akkeshi Bay, Japan, five specimens by Baba. The distribution thus is wide.



## EXTENDED ANATOMICAL DESCRIPTION.

*Alimentary system.* Two fine specimens received from Professor John E. Gubernet, University of Washington, taken at False Bay, San Juan Islands, July 12, 1940, and preserved in natural 5 percent formalin. First specimen, length over all 56 mm., maximum height 22 mm., maximum width 11 mm., length of foot 46.5 mm., tip of tail to posterior cerata 15 mm., tail flat. Second specimen, total length including a much contracted tail, 29.6 mm. These specimens were used in making extended anatomical descriptions. The following notes were made during the microscopic dissection:

Body wall thick, interspace between it and the viscera filled with delicate lacy network of connective tissue. Pharyngeal bulb pale yellow, measured before removal, 6.0 mm. over-all length. The remaining viscera had an approximate length of 12.3 mm. Heart, pericardium, and kidney removed to paracarminic dilute stain.

A large crustacean parasite was found on the left side beneath the pericardium. Its exact relationships were not clear as it was apparently free in the connective tissue immediately behind the pharyngeal bulb, above the oesophagus, and at the left of the adnexed genital mass in front of the stomach and liver.

The posterior half of the viscera is made up of the dark chocolate-brown lobes of the liver. The central nervous system and its nerves are very distinct. Immediately behind the heart, the fine intricate branchings of the kidney are seen extending down laterally and backward, well toward the end of the liver mass. The oesophagus, as seen from below, is back of the hinder tip of the pharyngeal bulb, curves to the left and dilates into the stomach. The intestine, lying in a deep groove, passes to the right in front of the anterior lobes of the ovotestis, curves downward and backward below the lateral lobes of the ovotestis on the ventral surface to the end of the liver, and makes nearly a right-angled turn passing upward and backward to the anus. The first portion of the intestine is marked by a number of prominent folds in its lining, two forming a larger typhlosole-like fold which dies away in the main curvature of the intestine.

The bulk of the liver lies on the left side posteriorly and is divided into a left antero-lateral lobe, *a*, and a larger postero-ventral one, *b*. The liver mass is brown, surface smooth, no ramifications to cerata exist, divided into major lobes, each of which shows lobular subdivisions on the surface. In ventral view, the anterior lobe appears as an elongated mass extending obliquely from the left to the right, behind in contact with the adnexed genital mass, and at the right passing beneath the intestine and showing indistinctly from the right side. In dorsal view, a small lobe shows at the left of the anterior group of ovotestis separated from the main liver mass by the proximal limb of the intestine which is passing forward. (Pl. 64, fig. 10.)

The stomach is cut open; on the ventral view, a wide duct opens into the stomach at its right anterior surface (pl. 64, fig. 10). This leads into a roomy cavernous system of branching spaces, the first branch, duct No. 1, passing forward into the left anterior lateral lobe; the remainder pass backward and ramify in the posterior ventral lobe; the spaces are wide and roomy. At first there is a continuation of the gastric lining which thins away in the smaller passages, having a sponge-like texture. The brown

glandular wall of the liver is thin, approximately 0.5 mm. in thickness.

Opposite duct No. 1, at the beginning of the greatest curvature of the stomach, is another liver duct, No. 2, on the lesser curvature. This leads into the ventro-anterior lobe of the liver which is exposed on the ventral face and lies in front of and inclosed in the lesser gastric curvature, in contact with the adnexed genital mass in front.

*Reproductive system.* (Pl. 64, fig. 4.) The exposed part of the glans of the specimens used measured 5 to 6.2 mm. long by .8 to 1 mm. wide. It protruded as a tapering conical organ, curved slightly upward. The surface is thickly set with low conical elevations or papillae, arranged in circles surrounding the glans. These projections are terminated by thorn-like points resembling in profile a low rose thorn, all directed outward, the tip being free from these (pl. 64, figs. 4, 5). From the inner end of the penis extends a strong retractor muscle passing across, behind, and above the coils of the vas deferens, to the opposite (left body wall) where it is inserted (pl. 64, fig. 8).

The lobes of the ovotestis lie to the right of the liver, each lobe a rounded mass composed of a number of closely appressed lobules.

The hermaphroditic ampulla, arising from the hermaphroditic duct, is 12.4 mm. long, and 1 mm. in diameter; after many convolutions it narrows and divides into the vas deferens and oviduct (pl. 64, figs. 4, 7).

The adnexed genital mass is somewhat conical in shape, widest near the body wall, terminated at the inner end by a large, elliptical, spheroidal spermatheca; the dorsal surface is flattened and slightly concave, the outer and lower surface convex.

The vas deferens is very long and coiled closely at the base of the glans penis, below its proximal end. The distal end of the duct is narrow, glistening, and muscular for about 10 mm. This segment is preceded by a long slightly thicker glandular part, likewise closely coiled, arising from the hermaphroditic duct at its point of division. (Pl. 64, fig. 4.)

The *vagina* (pl. 64, figs. 6, 9) is a roomy lumen 2.6 mm. long with an external diameter of 1.4 mm. It has a strong muscular wall with a circular sphincter muscle at the vulvar opening of the gland duct.

The *spermatheca*, ellipsoidal, 1.8 mm. maximum diameter by 2.6 mm. in length, lies at the inner posterior end of the adnexed genital mass. Its broad duct, at first 1.0 mm. in diameter, with clearly marked muscular wall encircling it, narrows slightly, then dilates, and doubles back upon itself, passing outward along the upper margin of the genital mass as a wide tube dilating somewhat as it approaches the vagina. (Pl. 64, fig. 6.)

## Family ZEPHYRINIDAE

### Genus *Antiopella* HOYLE

*Antiopella* HOYLE, 1902. Jour. Conch., London, vol. 10, p. 214, July 1. *Nom. nov.* for *Antiopa* Alder and Hancock, 1848 (not *Antiopa* Meigen, 1800. *Diptera*). Type (by monotypy) *Antiopa splendida* Alder and Hancock, 1849.

*Antiopella aureocincta* MACFARLAND, new species

Plate 57, figures 1-5; plate 63, figures 13-30; plate 64, figures 11-17

*Body* not at all compressed nor depressed, the notum slightly arched, rounded and broadest in front and tapering posteriorly to tip of the rather long tail, which may be quite shortened through contraction in preservation. Margin of notum overhangs the wall of the body everywhere, forming a well marked groove between it and the foot.

*Foot* broad, its margin thin and wide, but not reaching the width of the notum, widest in front, narrowing behind and tapering to the tip of the pointed tail. Anterior margin of foot rounded, smooth, forming the lower lamina of an apparently bilabiate structure, the upper lamina of which is formed by a lateral prolongation of the sides of the head fusing with the outer ends of the anterior margin of the foot. Between these two a well marked, transverse groove is formed, richly supplied with glands. (Pl. 57, fig. 2.)

*Anterior tentacles* short, blunt, cylindrical, borne midway on the sides of the head and directed obliquely outward.

*Rhinophores* stout, borne on the dorsal side of the head, directed outward and forward, the stalks cylindrical, dilating above into a fusiform perfoliate clavus with a blunted tip, bearing about 14 slightly oblique, well marked, parallel leaves, uniting behind in a narrow median ridge, not exactly opposite, with short intervening ones. (Pl. 57, fig. 5.) Their bases separated by a conspicuous median, short, elevated, longitudinal, comb-like ridge or crista inter-rhinophoralis, the superior margin of which is irregularly thickened and lobed, extending back to the line of the eyes.

*Dorsal papillae* very numerous, elongate, spindle-shaped processes, widened toward the base, slightly flattened from before backward. These are borne in thickly set longitudinal rows around the periphery of the notum, leaving its central area unoccupied, but meeting behind above the tail and extending around the anterior margin in front of the rhinophores in a continuous zone of shorter papillae. They radiate out from the body when crawling, the central ones curving somewhat toward mid-area, about 4 to 5, in an obliquely transverse row. The papillae are readily caducous and are quickly regenerated. The longest papillae are innermost and the outermost are much smaller in uninjured specimens. Isolated very small ones may occur on the dorsum well inside of the longest ones.

*Eyes* small, black, showing faintly through the integument just behind the rhinophore bases.

*Mouth* a longitudinal slit on the ventral side of the head, flanked by an inflated external margin.

*Statocyst*. In celloidin serial sections a statocyst (otocyst) was found having a diameter of 0.063 by .074 mm. A conspicuous otic ganglion in front of it contained a very large ganglion cell, 0.044 mm. in diameter, and a small number of lesser ones.

The stato-ganglion on the opposite side also was found which is separate from the cerebral ganglion. Bergh (1884, p. 18, pl. 9, fig. 6) figured an otocyst for *Janolus australis*; however, no details were given by him or others.

*Anal opening* far back on or close to the median line of the notum but within the zone of dorsal papillae, borne at the summit of a blunt, glandular, cylindrical papilla 1 mm. high.

The *renal pore* shows as a minute opening, well up near the base of the lowest cerata immediately behind the external reproductive openings. Its external rim is flush with the surface. The short and wide cylindrical *renal syrinx*, with deeply folded walls, opens into the posterior end of the pericardium through its ventral floor.

*Reproductive openings* close together midway of the right side, equidistant from anterior foot margin and lowest papillae, high at this point. The external opening wide with inflated margins.

*Penis* long, cylindrical, narrowed to the unarmed tip. Vas deferens long, in close coils; vagina short; hermaphroditic ampulla with a slender duct, arising beside the hermaphroditic duct, connecting a pyriform sac.

*Mouth and oral tube.* The ventro-lateral parts of the head are prolonged backward laterally as a thickened ridge which doubles forward to fuse with the anterior foot margin; medially this ridge extends across below the mouth where it is interrupted in the median line, thus forming an upper lip for the foot margin and giving it a bilabiate appearance. This upper lamina is deeply notched below the mouth opening in the median line.

The lip is thickly set with simple glands of varying size and length. Each is somewhat pear-shaped in outline, made up of a small number of cells lying in the connective tissue at different levels below the epithelium with which it is connected by a slender duct. This layer is continued along the upper margin of the foot to the angle at the side where they are especially large and closely packed. Internally the point of union of these margins correspond to the level of the hinder end of the pharyngeal bulb. Similar glands, more scattered, are found over the entire surface of the foot.

The cuticle of the upper part of the oral tube immediately in front of the mandible margin is very thick and colorless, and its outer surface is split up into a myriad of rod-like extensions, each one of which may be traced through the continuous layer of the cuticle to an epithelial cell from which it originated. This fringes the inner mouth opening.

In a specimen 14.2 mm. long, used for dissection, the pharyngeal bulb was depressed dorso-ventrally, elliptical from above; it measured 4.0 mm. long by 3.3 mm. broad. The dorsal edge of the heavy mandibles forms a sharply defined crest limiting the dorsal face of the bulb. The central nervous system rests upon the posterior third of the bulb. In front the two small buccal ganglia are seen.

Upon removing the muscular layer, together with the oesophagus and central nervous system, the radula sac is disclosed.

*Mandible.* A thick horizontal depressed plate, 3 mm. long, approximately triangular or rhomboidal in cross section. Inner thinner margin nearly straight, the outer thicker margin convex from front to back. Anterior end bent slightly upward, bearing a shield-like expansion. The shorter upper margin bears the hinge, the lower portion curved downward and backward forming the masticatory process, 1.3 mm. long, bearing upon its margin 8-14 large, strong, triangular teeth. (Pl. 63, figs. 18-22.)

The surface of the mandibles is covered with a chitinous layer, thicker in the hinge region, the masticatory process and the anterior portion thinning away posteriorly. Beneath this, and forming the larger portion, is a softer, nearly homogeneous substance.

A horizontal lamina of a coarsely fibrous nature divides the otherwise clear matrix of the mandible. On the external face it appears to be inserted in the high epithelium surrounding the mandible at that region. The lamina spans across the mandible in a compact mass until the inner fourth of the length is reached. Here the highly refringent fibers gradually separate out fan-shaped above and below the plane of the band and display a network of small elongated meshes. The fibrils become finer and disappear before the inner margin of the mandible is reached. The fibers are strongly refractive and seemingly elastic, apparently extending between the epithelial cells of the outer mandibular face. (Pl. 63, figs. 27, 28.)

The clear inner substance of each mandible appears to be divided vertically by a series of flattened prismatic blocks, in general parallel to the outer face of the mandible.

A substance supporting the heavy chitin of the masticatory process seems to be differently composed, being a reticulum with minute nuclei at nodal points and containing a few large blood-vessel-like cavities. (Pl. 63, fig. 30.)

*Radula.* Broad, deeply grooved, multiserial, 20 to 22 rows of teeth, each with 18 to 22 laterals on each side in hinder part of radula. Formula 20-22 (18-22·1·18-22). Median tooth (pl. 63, figs. 13, 15) quite small, its elongate base somewhat rhomboidal, thick and broadest near posterior rounded end, narrowing in front to about one-half its width behind, and thinning away with an irregular, broad, median notch in its anterior border. Median cusp compressed, blunt, the tip curved slightly downward, projecting beyond the posterior margin of the base, and flanked on either side by a row of six to eight irregular denticles beginning near the outer border of the base and extending obliquely upward along the sides of the lower part of the hook.

Lateral teeth (pl. 63, figs. 14, 16, 17) compressed elongate hooks arising from narrow bases, the innermost short, increasing progressively to about three times their height in the outermost ones, the hook becoming more slender and less curved. Tips of the innermost row occasionally bent somewhat toward the median series. First three inner laterals of each row with a series of 12 to 17 small pointed denticles beginning at the inner base of the hook and extending well up along its inner side. Occasionally a few similar denticles may be made out on the outer face of the first lateral, but they are inconstant and seen with difficulty.



*Salivary glands.* These are present. The ducts are found passing forward along the oesophagus between it and the pedal ganglion, curving outward toward the body wall. The glands branch out into a thin layer between the stomach and ventral portion of the adnexed genital mass opposite the external reproductive openings, giving off a less extensive system of terminal branches. The duct, lined by low, cuboidal, ciliated epithelium, opens just above the inner angle of the mandible into the bulb cavity opposite the anterior portion of the radula. Bergh (1884) indicates the presence of these glands in *Janolus australis*.

*Color* (pl. 57, fig. 1). General body color of Monterey Bay specimens a dusty-pink gray, inclining to a light dove color. Dorsum shows minute flecks of blue. Branches of liver show through the integument as pale, raw-umber bands, lighter or darker along the dorsum and into the dorsal papillae. Tips of the papillae pure white encircled below by a band of yellow-orange. Inter-rhinophorial crest tipped with yellow-orange. clavus plates of rhinophores light yellow. Dorsum of tail with a narrow, median, longitudinal band of white.

In specimens from the Newport Bay region, the cerata tips, distal ends of rhinophores, and median dorsal band of the tail are blue (permanent blue, winsor and newton's). The whole animal thus displays a more brilliant appearance than the specimens from the Monterey Bay region. The orange color of the cerata and of the inter-rhinophorial crest is a rich golden yellow, almost metallic in its lustre, which on the ceras forms a circlet limited to the surface of the organ. The general body color, a soft dove gray; the clavus of the rhinophore a pale yellow.

*Dimensions.* Length of large living specimen 21.0 mm., greatest width 4.0 mm., length of foot 19.0 mm., its greatest width at anterior end 4.0 mm. Length of rhinophores 4.0 mm. Specimens range in length from 13 to 25 mm.

Length of largest specimen after preservation 19.6 mm. over all.

*Habitat.* Taken at intervals mainly during the summer months in rocky tide pools on algae or floating on the quiet surface at low tide along the southern margin of Monterey Bay and the coast line to Point Lobos. Not common. Also reported by Johnson and Snook (1927) from La Jolla. Two specimens from Los Angeles Museum taken at La Jolla by H. R. Hill were also studied. Taken in Newport Bay on piling of yacht harbor in April, 1946.

#### EXTENDED ANATOMICAL DESCRIPTION.

*Hepatic system.* (Pl. 64, figs. 16, 17.) The main mass of the liver lies anterior of the ovotestis. Three bile ducts arise there from the stomach.

Duct No. 1 arises from the anterior ventral side, passing upward and outward, ramifying to the subdivisions and ending in a terminal branch to each ceras on the left side of the head.

The second large hepatic duct, No. 2, arises from the mid-ventral curvature of the stomach, passes backward on the left to a median position, sending off lateral



branches to the posterior groups of cerata on the left side.

From the right anterior curvature of the stomach arises a large duct, No. 3, which bifurcates at once, sending a large branch forward supplying the cerata of the right anterior cardiac groups; the posterior one passes backward, two-thirds of the body length, on the right posterior side, the paired terminal branches entering the cerata of the transverse rows. From the very large median duct, No. 2, there arises a subdivision, posterior of the ovotestis, which reaches the groups of the extreme posterior right side.

The main longitudinal hepatic ducts pass along the bases of the groups branching dichotomously, one stem entering the center of each ceras. These branches are usually single, passing to the tip; not dilated nor divided as given by Vayssi re for *Janus cristatus*.

This condition seems to apply to the specimens of Monterey Bay; however, in collections made farther south, the tubules of the cerata had nodules and small branches along the stem which often terminated in branches at the tip. (Pl. 57, figs. 1, 3, a, b, c.)

*Reproductive system.* (Pl. 64, figs. 11, 12, 13.) One specimen 11 mm. long by 4.4 mm. wide was used for serial sections. Another specimen which had a 19 mm. foot-length by 7 mm. wide anterior end, and external reproductive opening 8 mm. from anterior end, was taken for dissection. Without unnecessary disturbance of the parts of the adnexed genital mass, dissection was done and the description written.

The anterior margin of the adnexed genital mass is formed by the preputium, a long conical sac curving in an approximate semicircular form on the antero-dorsal surface. Within, and upon its curve, a portion of the prostate is coiled in tight loops, the remainder lies below. Arising from the dorsal body wall, a strong retractor penis muscle is attached to the base of the preputium.

The inner face of the adnexed genital mass is slightly concave; the lower surface is formed by the lobes of the mucous gland, above is the proximal wide end of the preputium, and the shallow groove between the two is closed behind by the reniform hermaphroditic ampulla.

On the anterior margin, in this groove, lies a pyriform sac, 1.8 mm. long by 1.5 mm. wide, with a deeply lobulated surface. A slender duct 1.5 mm. long extends from it backward along the middle of the groove to the hermaphroditic ampulla where it arises as a branch of the small hermaphroditic duct. (Pl. 64, fig. 13.)

At the opposite end of the reniform ampulla, a slender duct is given off, 0.6 mm. in length, dilating into the thick-walled prostatic portion of the vas deferens. Just before this point is reached, there is given off the short oviduct at a sharp angle which passes at once into the gland mass into the cavity from which the vaginal duct also leads. (Pl. 64, fig. 11.)

The gland mass is a flattened tube with the glandular walls folded lengthwise and thrown into irregular loops.

The female vestibule passes obliquely upward and backward, receiving the duct of the albumen-mucous gland complex upon its ventral side, the dorsal side being pro-

longed into the short vagina. The wall is thick and muscular, with longitudinally plicated ciliated epithelium. It narrows proximally, passes forward, and ends blindly. Into the loop of this curvature opens dorsally a narrow thin-walled tube which extends obliquely forward. (Pl. 64, fig. 14.)

The wall of this tube contains a very thin layer of muscular fibers and is lined by columnar ciliated epithelium. It expands at once into a lumen (pl. 64, fig. 14) which is incompletely divided into a system of irregular, communicating, alveolar spaces by a system of thin septa covered by ciliated epithelium, the free margins of which are somewhat thickened. In the proximal end this lumen suddenly narrows, opening into the hermaphroditic duct which, at the same time, gives off the very short vas deferens. This dilates almost at once into the prostatic segment. (Pl. 64, fig. 14.)

The preputium is a long thin-walled sac, wide in its proximal half, tapering to a slender distal end where it opens on the right side midway of the body length. The glans penis, receiving the vas deferens at its dilated posterior end, is long and conical, tapering to a pointed unarmed tip. Its central lumen is narrow, lined with low, columnar, ciliated cells, surrounded by thick layers of muscular fibers. Between these there is a zone of connective tissue carrying large blood sinuses.

## Family FLABELLINIDAE

### *Flabellinopsis* MACFARLAND, new genus

Genotype, *Aeolis* (*Phidiana*?) *iodinea* COOPER, 1862.

Body elongate, much compressed, tapering, cardiac region high; foot narrow, its anterior angles produced into tentacle-like appendages.

Rhinophores claviform, perfoliate, numerous thin plates; anterior tentacles long. Cerata numerous, rounded, tapering; borne in well defined groups upon low elevations of the margin of the dorsum, becoming less distinct posteriorly, the first group extending laterally to the base of the rhinophores.

Masticatory margin of mandibles armed with many low rounded nodosities in irregular rows, largest on margin. Radula triseriate, the laterals wide, their inner margins denticulate.

### *Flabellinopsis iodinea* (COOPER)

Plate 58, figures 1, 2; plate 65, figures 1-8; plate 66, figures 1-6

*Aeolis* (*Phidiana*?) *iodinea* COOPER, 1862. New Species of California Mollusca. Proc. Calif. Acad. Nat. Sci., vol. 2, p. 205.

*Flabellina iodinea* (Cooper), BERGH, 1879. On the Nudibranchiate Gasteropod Mollusca of the North Pacific Ocean, with Special Reference to those of Alaska. I. Proc. Acad. Nat. Sci. Philadelphia, vol. 31, pp. 79-81, pl. 1, figs. 15-17; pl. 2, fig. 16. O'DONOGHUE, 1922. Notes on the Taxonomy of Nudibranchiate Mollusca from the Pacific Coast of North America. Proc. Malacol. Soc. London, vol. 15, pp. 138, 139.

*Body* very much compressed and high; elongate, linear, tapering to a rather abruptly pointed tail. Head sloping sharply from the rhinophores. Cardiac region prominently rounded.

*Foot* long, narrow, a thin extension sharply marked off laterally from the sides of the body by a well defined groove, its anterior angles prolonged into short, strong, recurved tentacles carried outward or backward when crawling, at the base as broad as true tentacles. their anterior faces grooved from base to tip, the posterior margins of this groove carried across and uniting below the mouth. (Pl. 58, figs. 1, 2.)

*Anterior tentacles* slender, elongate, about one-fourth to one-third the length, graceful; kept in constant motion.

*Rhinophores* thickened, tapering to a blunt tip, with a very narrowed base. Broad clavus, slightly flattened behind, convex in front, finely laminate as in many dorids, about 46 half plates on either side, arising in front and behind from a narrow median ridge. Leaves thin, inclined slightly from horizontal, extending to the base.

The *cerata* are in groups borne upon low, crescentic, ridge-like elevations of the dorso-lateral body margin. The longer *cerata* near the center of the dorsum decrease in size laterally. The individual *ceras* is cylindrical, narrowing at the base, elongate, tapering toward a bluntly pointed tip. The axial region of each is occupied by the hepatic process, closely lobulated, narrowed at the base, terminating in a narrowed point about one-third the distance below the tip.

They are arranged in obliquely transverse rows grouped in 8 paired clusters. The first group, with 21 *cerata*, is between the head and heart, terminating anteriorly immediately below the rhinophore base, extending upward and backward in a gentle curve, the concavity directed outward, along the sides and back to the anterior cardiac region. In the second group 12 *cerata* occur, 7 in the third and fourth, and a lesser number in the remainder, often more clearly defined than the anterior groups. The length of the expanded bases, with the intervening spaces, is proportional to the number of *cerata*, as the base of the first group is 7 mm. long, and its pericardial area 3 mm., second base is 4.5 mm., 2 mm. the space to the third, and so both decreasing proportionately to the last group.

*Eyes* large, showing through the integument at the base of the rhinophores. *Otocyst* containing a great number of very small rod-like otoconia. *Otocyst* diameter inside, 0.09 mm.; outside, 0.908 mm.

Lips thick; *mouth* at the ventral base of the true tentacles, T-shaped, a median ventral furrow uniting with groove in front of foot.

*Amus* just below, outside of the posterior of the second group of *cerata*. The tubular opening upon a .5 mm. papilla, 4.3 mm. back of the renal opening.

The *renal pore* equally distant between the reproductive openings and anal papilla, close to the anterior end of first post-cardiac group.

*Reproductive openings* on the right side slightly behind and below the middle of the first group of cerata.

The blunt conical tip of the penis projects from the external opening.

*Color.* (Pl. 58, figs. 1, 2.) Body color everywhere is a clear translucent purple of a most exquisite shade. The foot, projected against white, is blue-violet.

The anterior tentacles and the tail shade gradually from the body purple to a paler hue terminated by brilliant blue tips.

The rhinophore base is of the body color. The leaves of the clavus, a deep shade of garnet or maroon mixture of red-orange and violet. The plates terminate against an anterior median ridge marked by a narrow, encrusted, white line. Numerous thin flat plates are placed the entire length of the clavus, at right angles.

This organ is most striking, being dark to the tip, contrasting with the brilliant cerata.

The cerata have one-fourth to one-third of the basal portion of the body violet, shading gradually into a flaming scarlet or very brilliant orange.

The axis of each ceras is occupied by a narrow, closely lobulated, hepatic process, burnt sienna in color, narrow at the base, widening in the center with a narrow tip above.

This is the most striking of all aeolids and most difficult to truly represent.

*Mandibles.* The pharyngeal bulb small, ovoid, 2.1 mm. long, 1.5 mm. wide, 1.5 mm. high; mandibles shorter than bulb. They are thin, delicate, dark brown, covering the anterior end of the small bulb, strongly concave toward the mouth, anterior end with thickened hinge, posterior bluntly conical. Masticatory surface wide, free edges turned inward, upward, and backward, presenting a broad surface on either side for trituration of food. Over-all width, 1.19 mm.; length, 1.6 mm.; wing, .96 mm. long from top to tip; masticatory edge, .88 mm.; free end of process .32 mm.; the inner surface thickly set with nodosities, largest on the free margin. (Pl. 65, figs. 1, 2.)

*Radula.* In a specimen 31.5 mm. long, the radula is triserial, 1.7 mm. long, five median teeth to the angle, three in addition to a sheath edge, making eight functional teeth, under the sheath nine, making 17 rows in all. Median tooth almost an equilateral triangle in form, with a horseshoe base, the main cusp rising at an angle; each side bears numerous denticles, 12 to 15, nearly equal in size to the median point and on the same level. (Pl. 65, figs. 3, 4, 8.)

Lateral teeth flattened, roughly triangular, with one side extended; central cusp strong, rising in a curve, extending well above the lateral denticles which are closely set and slender. (Pl. 65, figs. 5-7.)

*Dimensions.* *Living specimen* large, body 70 mm. long; over-all length 82 mm., height 7 mm., width 12 mm., rhinophores 12 mm. long, anterior tentacle 22 mm. long. Average size: body 35 mm. long; over-all length 44 mm., height 4 mm., rhinophore 4 mm. long, anterior tentacle 10 mm. long. Average living length 25 mm. to 39 mm.

*Alcoholic specimen.* Body 31.8 mm. long, height 10 mm., width 5.5 mm., anterior tentacle 5.8 mm. long, oral tentacle 2.3 mm.

*Habitat.* Found living on hydroids during the summer months. Taken most often from the piles of Monterey Bay wharf, Cabrillo Point, Point Pinos, and Pescadero Point where very large specimens were found by W. K. Fisher and F. W. Weymouth. Taken as far north as Puget Sound, and as far south as Santa Barbara and San Diego.

In the aquarium this species displayed characteristic habits of swimming; folding the margins of the foot together, it swims freely by doubling the body laterally from side to side until head and tail meet, frequently attaching the tail to a bit of ulva, extending the body full length, waving back and forth in graceful motion. The thin flat body is strikingly so when in such rhythmic motion.

#### EXTENDED ANATOMICAL DESCRIPTION.

*Alimentary canal.* The oesophagus is very short, passing at once into the capacious stomach at the left of the genital mass. There are two hepatic branches arising close together from the upper, anterior, lateral surface of the stomach. The salivary gland extends along the lower right side.

*Kidney* finely ramified over the dorso-lateral portion of the viscera, in front extending down behind the anterior genital mass on the right. It fits down closely between the lobes of the ovotestis, and lies left of the alimentary canal, its lobes surrounding it. A capacious sac is formed below the pericardium. The renal syrinx, the opening into the pericardium, is on the posterior right side. A median dorsal tubular extension of the renal sac passes posteriorly between the lobes of the ovotestis just above the hermaphroditic duct. From this the ramifications arise.

*Reproductive system.* (Pl. 66, fig. 2.) The closely set lobes of the hermaphroditic gland fill the posterior two-thirds of the body. The duct receives branches from each of these, passing forward to the posterior margin of the elliptical adnexed genital mass. Upon the flattened inner face of this the vas deferens is looped in irregular coils, its distal end entering the large muscular preputial sac situated on the anterior of the complex. The posterior portion of the mass is formed by the albumen-nidamental glands, overlain above and behind by the loops of the hermaphroditic ampulla and the dilation of the small hermaphroditic duct. The common duct beyond the ampulla branches at the turn into the vas deferens and oviduct (pl. 66, fig. 1), the latter passing into the gland complex. A spermatheca was not found.

The vagina duct is large and dilates into a spherical mass with muscular walls. Within this is found a roomy cavity almost filled by a large, curved, pear-shaped mass which appears to be attached distally, close to the opening of the vestibulum, by two, thin, flattened lips. The proximal end dilates into a blunt club-shaped mass with slightly irregular surface.

Into one side of the proximal end of the cavity opens the vaginal duct. (Pl. 66, fig. 1.) The dorsal wall of the vestibulum is removed, together with the mass which



filled it, and a set of longitudinal folds near its opening are revealed, another set one-third of the way in, and a third near the bottom of the sac. These two latter sets extend around the circumference of the tube and are in the form of short elevations. The vestibulum is 2.7 mm. in length by 1.4 mm. diameter.

The external surface of the preputium is strongly muscular, 2.2 mm. in length by 1.5 mm. in diameter, cylindrical in form, the vas deferens entering in a depression on the inner surface. The lining of the preputium consists of tall columnar epithelium, glandular at the outer margin, giving way to low cuboidal cells with long cilia which also cover the glans.

The cavity of the preputium is filled by the thick bluntly conical glans, 1.4 mm. in length by 6 mm. in diameter; the tip is a circular disk .7 mm. in diameter.

The vas deferens is a long, thick-walled tube, coiled in a series of windings between the adnexed genital mass behind and below, the penis in front, resting in part upon the duct of the glans. (Pl. 66, fig. 2.) In section it shows a lining of high columnar glandular cells, crowded with a fine granular secretion. Nuclei are at the base. Another series of nuclei, occurring midway of the height of the epithelium, apparently belong to slender ciliated cells intermingled with the glandular ones. Their stiff cilia project into the lumen.

In paraffin series, the glans is cut nearly lengthwise. It is a strong muscular organ, nearly cylindrical, and with the distal end abruptly truncate, the margins slightly dilated. (Pl. 66, fig. 1.) The lining of the preputial sac and the surface of the glans are formed by a single layer of low cuboidal epithelium, uniformly ciliated; these are three to four times as long as the height of the cells bearing them. The vas deferens opens externally at the center of the truncate end with no trace of any armature being visible.

The wall of the glans is made up of intermingled longitudinal and circular muscle fibers, less abundant in the axial region where the sinuous duct is situated, accompanied by a well developed blood sinus. In general, an outer circular layer and an inner longitudinal layer of muscle fibers may be recognized. The duct is accompanied by a well defined, circular, muscular sheath. At the base of the glans the epithelial lining becomes quite high, the cilia sparser, and the cell protoplasm filled with small, deeply staining granules. Two zones of nuclei are seen, a basal series of round ones of fair size, and a zone of smaller elliptical ones midway the thickness of the epithelium. These latter are apparently wedged in between the larger granular cells.

The lateral surface of the glans appears entirely smooth; when it is found everted in preserved material, it presents a conical form. The distal end, bounded by a white ring, is 1.2 mm. broad; the basal portion is narrowed to one-third or less of its former diameter, being 0.5 mm.

A specimen from San Diego was observed to have a partly everted glans which was bell-shaped, the tip a flattened disk with rounded margins sharply set off from a lighter ring, bounding the central area surrounding the opening of the canal; this ring is narrow, slightly elevated, and glistens as if chitinous. (Pl. 66, fig. 3.)

Behind and above the male opening are the female genital openings, crescentic



in form. The glans was stained in paracarmine, cleared, and stripped of the outer muscular layers. No trace of a stylet, such as described and figured by Bergh, can be found, nor of any form of armature, Bergh (p. 76, pl. XLV, figs. 3, 4).

### Genus *Coryphella* GRAY

*Coryphella* GRAY, 1850. Figures of Moll. Anim., London, vol. 4, p. 109. Genotype, *Eolis rufibranchialis* Johnston, 1832.

*Generic diagnosis.* Body elongate, slender; anterior angles of foot produced; anterior tentacles smooth, long, tapering; rhinophores usually smooth or wrinkled, but may be perfoliate.

Mandibular margin (masticatory margin of mandibles) with several rows of denticles.

Radula triseriate, the median tooth with a large central spine, the laterals triangular, denticulate or not on their inner margins.

Cerata in groups of dorso-lateral transverse rows.

### *Coryphella pricei* MACFARLAND, new species

Plate 58, figure 6; plate 65, figures 9-13; plate 66, figures 8, 9

*Body form* compressed, arched above, moderately high in the cardiac region, tapering uniformly behind to the tip of the short pointed tail, in front gently sloping to the anterior margin of the head.

*Foot* widest in front, thence tapering backward, its margins rather wide and distinctly set off from the sides of the body. Anterior corners of the foot continued into rather stout, tapering, pointed prolongations, habitually curved backward while crawling. The ventral surface of each of these is deeply grooved lengthwise, the groove being continued across the anterior margin of the foot and uniting with that of the opposite side, the upper lip of the groove being notched deeply in the median line below and behind the mouth. (Pl. 66, fig. 9.)

*Anterior tentacles* arising from broad bases, long, slender, cylindrical, tapering distally to blunt tips, directed horizontally forward and outward, and kept in constant tactile motion while crawling.

*Rhinophores* erect, cylindrical, tapering abruptly at their tips, the bases close together, perfoliate, the distal half bearing eight to ten complete, or nearly complete, low, shelf-like rings encircling the shaft, alternating with which are about the same number of incomplete half-rings limited to the posterior surfaces of the rhinophores. The tip of the clavus terminates above the uppermost ring in a blunt point. Rhinophore ganglion relatively large, with short cerebral connectives, two nerves arising and passing to rhinophore.

*Cerata* slender, cylindro-conical, slightly flattened laterally, directed obliquely backward, arranged in nine to twelve or more transverse, dorso-lateral rows, well sepa-

rated behind the cardiac area in fan-shaped groups springing from a common stalk, but in front more closely arranged in a single pre-cardiac group made up of from five to eight transverse rows. The *cerata* of each transverse row are borne upon an obscurely elevated, common base. The anterior rows, of usually quite short *cerata*, are outside of and opposite the bases of the rhinophores, in the remaining rows of the pre-cardiac group the number of *cerata* increases to about eight in the last row. In the first post-cardiac row, the number of *cerata* may reach nine, but decreases successively in the following rows to the hindmost, which may have two or but one. The shortest *ceras* of each row is external, the length increasing toward the middle line of the body. Inner ends of the transverse rows opposite, approaching each other toward the posterior end of the body but leaving the median dorsal area free throughout.

The following table gives the number of *cerata* in the transverse rows of right and left sides in a preserved specimen 8 mm. in length.

Number of row	<i>Pre-cardiac group</i>						<i>Post-cardiac group</i>					
	1	2	3	4	5	6	7	8	9	10	11	12
Right	3	4	5	6	6	6	10	8	6	3	3	1
Left	3	4	6	8	8	8	8	8	6	6	3	1

*Eyes* minute black dots showing through the integument close behind the bases of the rhinophores. Eye close against the outer face of cerebral ganglion in front of pedal; behind the eye and in close contact is the otocyst.

*Mouth opening* an oval longitudinal slit, its margins not much inflated, the lower posterior margin incomplete, communicating with the notch in the anterior margin of the transverse groove of the anterior end of the foot.

*Anal opening* dorso-laterally at the summit of a short tubular papilla below the dorso-lateral margin of the back, slightly above the lowermost *cerata* bases of the first right, post-cardiac row of *cerata* at the beginning of the posterior fourth of the cardiac interval between the *cerata* groups.

*Renal opening* a minute inconspicuous pore close in front, 0.15 mm., of the anal papilla.

*Reproductive openings* on right side below the middle of the pre-cardiac group of *cerata*.

*Color.* (Pl. 58, fig. 6.) General ground color of living animal a clear translucent gray, the ovotestis lobules, when mature, showing through the integument as pale yellowish-pink masses. Some specimens have a cream cast and show a pale red-orange spot on the top of the head. The axis of each *ceras* is occupied by a deep olive-green band, this diverticulum of the liver, continuing distally nearly to the tip of the *ceras*, and proximally uniting with a basal line of the same color, which gives off similar branches to each *ceras* in the row. In the post-cardiac *cerata* rows from near its median end, this basal line of green is continued downward laterally, curving around the lobes

of the ovotestis to a median ventral band of a similar color, which can be followed forward more or less clearly to its origin from the posterior portion of the stomach. The cerata of the pre-cardiac group have a similar axis of dark green arising from a transverse band at the base of each row. The basal bands unite at their median ends with a lateral band on either side, which passes backward to the stomach.

The tip of each ceras is encrusted with white, below which is borne a subterminal band of rich deep brown, becoming yellow and diffuse on its lower margin.

The anterior tentacles are translucent gray, sprinkled with encrusting dots of white. The outer half of the rhinophores tends to a pale yellow-green upon the translucent-gray ground color.

The mandibles show faintly through the integument from above, their darkest hinge region taking on a greenish tinge.

In preserved specimens the subterminal ring of brown of each ceras is permanent in alcohol, the remaining color markings disappearing.

*Internal anatomy.* Mandibles (pl. 65, fig. 9, *a, b, c*) pale amber, oval, thin and delicate, somewhat thickened in the hinge region and along the antero-dorsal border, the maximum width 0.5 mm., the length 0.8 mm. The anterior masticatory margin of the mandible is thickened, its lower process but slightly developed. The margin and process bear a single series of small blunt denticles, very minute and worn near the hinge but becoming somewhat larger as the process is reached. The individual denticles are broad in an antero-posterior direction. Some 26 of these teeth may be counted in the mandible of a large specimen.

A nearly transverse section of the approximated cutting edges of the mandibles is shown in plate 65, figure 9, as drawn from a celloidin series of the animal. The slight obliquity of the plane of section increases somewhat the apparent thickness of the margin. No indication of more than a single series of denticles.

*Radula* (pl. 65, figs. 10, 11, 12, 13) short, narrow, triseriate, composed of about nineteen transverse rows of teeth. Of these the oldest five are in front below the angle of the radula, one at the angle, and thirteen proximal to it, nearly all of the latter being within the sheath, and the last two immature at the tip. Median tooth triangular from above, the strong median cusp depressed below the level of its well developed lateral denticles, six to eight in number on either side. Base of median tooth prolonged forward laterally, giving it a deep U-shape or horseshoe form. Lateral teeth simple, flattened, thin, oblique, triangular plates, the inner and outer margins meeting above in a sharp point which is slightly curved downward, the inner margin smooth and nearly straight, the outer slightly curved and prolonged to meet the oblique, slightly concave, basal margin. The teeth do not vary much in size from one end of the radula to the other. In length the median teeth range from 0.07 mm. to 0.077 mm., the width varying from 0.04 to 0.044 mm. The length of the laterals averages 0.087 mm., the width 0.033 mm.

*Reproductive system.* (Plate 66, fig. 8.) Vas deferens short, dilating promptly into a thickened, glandular, prostatic portion, which, after a short nearly straight course, joins the preputial sac. Glans penis at base of preputium short, bluntly conical, and entirely without armature. Vagina leading by a short duct into the nidamental-albumen gland complex, receiving near its external opening the relatively long duct of the ellipsoidal bursa copulatrix or spermatheca. The adnexed glandular portion opens close below the vaginal aperture, the opening of the preputium being immediately in front of the two.

*Dimensions.* Maximum length of active living specimens 15.5 mm., height in cardiac region 3.5 mm., greatest width of body 2.5 mm., greatest breadth of foot 3.0 mm., length of anterior tentacles 4.0 to 5.0 mm., length of rhinophores 3.0 mm. It must be borne in mind, however, that measurements are of necessity more or less approximate, since the degree of extension of the whole body and of its parts varies constantly, and the slightest touch causes local or general contractions.

In preserved specimens the unavoidable shrinkage reduces the above measurements to a variable degree, the total length ranging around 8.0 mm., the height in the cardiac region 3.0 mm., the width 2 to 3.4 mm., the breadth of the foot 2 to 2.4 mm., the length of the anterior tentacles 2 to 2.5 mm., and the length of the rhinophores 1.5 to 2 mm., while the free portion of the foot angles reaches 0.6 to 1.0 mm. in length.

*Habitat.* *Coryphella pricei* has been taken in relatively small numbers in and near Monterey Bay in rocky tidepools, well out beyond extreme low-water mark, upon bryozoan or hydroid colonies, crawling upon submerged algae, or floating at the surface of quiet pools. Rare.

#### EXTENDED ANATOMICAL DESCRIPTION.

*Alimentary canal.* The short mouth tube leads into the small, nearly spherical, pharyngeal bulb containing the radula and mandibles. The end of the radula sac is not visible externally. From the upper, posterior face of the bulb, the oesophagus emerges, passes upward and backward, and at once dilates into the large, thin-walled stomach. On either side of the posterior portion of the bulb are the branched, tubular, salivary glands, the ducts of which open dorsally into the bulb close to the exit of the oesophagus.

From the antero-dorsal sides of the stomach arise the right and left anterior bile ducts, each passing upward and outward and ramifying to the subdivisions of the liver which end in the pre-cardiac groups of cerata. The lining epithelium promptly changes to the liver-cell type as the ducts emerge from the stomach and before the branches to the cerata are formed, so that the liver tissue is not limited to the terminations, but extends centrally well toward the stomach. This is shown externally in the living specimen, since the characteristic green pigmentation of the liver cells may be followed almost to the stomach itself. At the posterior end of the stomach, a large median bile duct is given off from a funnel-like enlargement. It passes downward and backward below the ovo-

testis lobes, giving off, at intervals, paired branches which pass upward laterally to the bases of the successive transverse rows of cerata, sending a liver branch to each. Characteristic liver cells appear in this duct also close behind its origin from the stomach, and continue out to its ultimate ramifications. At the tip of each ceras, a cnidosac communicates with the axial branch of the liver and opens externally by a minute apical pore.

Immediately behind the entrance of the right bile duct, the stomach contracts above into the intestine which passes laterally downward to the ventral part of the pseudocoel, makes an abrupt turn upward, and courses nearly vertically to the dorso-lateral anal opening in front of the first post-cardiac row of cerata on the right side. A prominent longitudinal infolding of the lining of the intestine forms a typhlosole throughout its extent.

*Excretory system.* The kidney consists of a thin-walled, elongated, flattened sac lying above the other viscera and extending from below the anterior end of the pericardium backward to the end of the body. Irregular diverticula extend out from it laterally and dorsally, and the whole is surrounded by cavernous blood sinuses. It is lined by a low, clear, cuboidal epithelium. Just in front of the junction of auricle and ventricle, the renal syrinx opens into the right floor of the pericardium. It is a thick-walled, nearly cylindrical tube 0.25 mm. long by 0.08 mm. wide, and is lined with cuboidal cells bearing very low cilia. It leads slightly obliquely backward and outward and opens at its distal end directly into the roomy renal sac which here extends across the body below the pericardium, overlapping the anterior genital complex and the anterior lobes of the ovotestis, in places extending half way down the side of the pseudocoel. The very short renal duct arises close behind the syrinx from the dorso-lateral wall of the kidney sac, and passes directly outward to the body wall where it opens externally by a small pore immediately in front of the anal opening.

*Reproductive system* (pl. 66, fig. 8) with adnexed glands removed. The lobules of the ovotestis fill the posterior body cavity fully in the mature specimen and show through the integument with a pinkish hue. Each lobule is made up of a main spermatogenic follicle into which numerous, peripheral, ovigerous follicles open, both containing the respective reproductive cells in various stages of development. These lobules communicate by short ducts with the median hermaphroditic duct, which passes in a fairly direct course forward in the median line of the body, above the posterior median bile duct of the liver, and below the kidney and pericardium to the anterior genital complex. Here it dilates at once into the hermaphroditic ampulla, a cylindrical sac 1.2 mm. long by 0.15 mm. in diameter, extending diagonally forward in a deep groove between the right and left lobes of the nidamental gland.

In front it narrows into a short slender duct which at once divides into the oviduct and the vas deferens. The oviduct immediately opens into the cavity of the nidamental gland, while the vas deferens, at first slender, dilates into a thick-walled glandular segment, the prostate, 0.135 mm. in diameter and about 1.2 mm. in length. It is di-



rected nearly straight forward for almost its whole extent, parallel with the preputium into which it opens at its proximal end after bending sharply backward to meet it. The preputium is a nearly cylindrical sac with muscular walls, 0.73 mm. in length and 0.195 mm. in basal or proximal diameter, from which region it tapers gradually to the external male opening.

Attached to the base of the preputium and inclosed within it, is the short bluntly conical glans penis, 0.28 mm. in length and 0.15 mm. in basal diameter, at the tip of which is the opening of the deferent canal. The glans is entirely free from an armature of any description and is covered with long cilia, such as are also found lining the preputium throughout its whole extent.

Close to the entrance of the oviduct into the nidamental-albumen gland emerges the vaginal duct, a slender tube, 0.067 mm. in diameter and about 0.3 mm. in length. It curves around beneath the distal end of the hermaphroditic ampulla and dilates gradually into the vagina, a straight tube passing obliquely forward and outward to its external opening behind that of the preputium and above that of the duct of the adnexed glands. Its diameter midway of its extent is about 0.105 mm., gradually increasing distally, its length is approximately 0.3 mm. At the outer opening its walls become more deeply folded, and it receives posteriorly the duct of the spermatheca, or bursa copulatrix, which closely parallels the course of the vagina.

### ***Coryphella fisheri* MacFarland, new species**

Plate 58, figures 3-5; plate 65, figures 14-18; plate 66, figures 10-20

*Body form.* Limaciform, somewhat compressed, the back rounded, body broadest and highest in the prominent cardiac region, tapering backward to the tip of the rather long tail.

*Foot* narrow, its narrow edges distinct from the sides of the body. Anterior angles of the foot prolonged as short, pointed tentacles directed outward and backward, ventral surface not grooved.

*Anterior tentacles* moderate in length, tapering to blunt tips, directed horizontally forward and outward; frontal margin between the anterior tentacles convex.

*Rhinophores* longer than anterior tentacles, their bases well separated, uniformly tapering throughout to the blunt tips, the distal two-thirds perfoliate with about 7 to 10 ring-like lamellae extending entirely around the clavus; alternating with these are half-ring narrower lamellae borne only on the posterior face of the clavus, the total number of lamellae approximating 14 to 20. These are flat plates, saucer-like, which stand out at right angles from the stalk.

The *eyes* show through the integument as two small black dots close behind and slightly medial to the rhinophores. Statocysts found, .042 mm. by .054 mm.; several statoliths counted, .008 mm. long.



*Cerata* lanceolate, rounded in cross-section, the tips pointed, arranged in transverse dorso-lateral rows in six to eight opposite groups, leaving the mid-notum free. The first group, borne upon low elevations, made up of six closely set rows, one in front of the cardiac elevation and well behind the bases of the rhinophores, the remaining groups are post-cardiac in position and spaced at regular intervals. The number of rows in each group decreases from six or seven in the most anterior, to two or one in the hindermost. The cerata are fewest in the first row of each group and progressively increase, reaching four or five in the last row of the first group, and two or three in the posterior ones. The innermost cerata of each row are the largest and longest, the size progressively decreasing outwards, often to a rudimentary one.

*Mouth.* The mouth opening is bounded by a rather inflated, oval lip disk. Anterior contour of head convex. When the mouth region is stretched forward, the sides of the lip disk may give the appearance of a notch in the front margin which is not there.

*Anus* at the summit of a low blunt papilla immediately below the anterior end of the first post-cardiac group of cerata, and above the lateral white line of the body.

*Renal pore* very minute, a short distance in front of the anus.

*Reproductive opening.* A single external opening for the reproductive organs is borne upon a thickened, nearly circular elevation projecting above the surface just below the anterior half of the anterior group of cerata of the right side.

*Pharyngeal bulb* in a 12 mm. specimen, 2.4 mm. long by 1.5 mm. wide by 1.5 mm. high.

*Mandibles* (pl. 65, figs. 14, 15) convex, oval in general outline, broadest in front, the ventro-posterior margin nearly straight, the dorso-anterior border strongly curved, the hinge region strong and thickened, the masticatory margin triangular, its inner surface convex, prolonged into a quite short process below. Inner surface of the margin covered with short, closely set, bluntly conical denticles arranged in approximately longitudinal rows.

In the upper, older half of the denticulate area the denticles are arranged in about four or five obscurely defined rows; in the lower half this regularity or arrangement is lost as the area widens, but about ten to twelve rows may be made out, in large specimens about 40 marginal denticles being counted. The outermost marginal row contains the largest and strongest denticles, the remainder decreasing progressively away from the margin. (Pl. 66, fig. 20.)

Over-all length of mandible in a large specimen 0.945 mm., maximum width 0.7 mm., length of masticatory margin 0.4 mm., greatest width of armature 0.044 mm., maximum height of denticles 0.007 mm.

*Radula.* (Pl. 65, figs. 16, 17, 18.) Triseriate, short and moderately wide, about 1.0 mm. in length in typical adult specimens, the anterior end bent backward in a curve

rather than at a sharp angle. Teeth in 17 to 18 transverse rows, of which five form the oldest ventral limb of the angle, while 12 to 13 extend from the angle back to the tip of the sheath, the last one being incompletely developed at the blind end, formula being 18 (1·1·1) 18. Total length of radula 1.05 mm.

The median tooth is of horseshoe-shape at the base, its cusp prolonged upward and backward into a strong point slightly depressed. On each side of the cusp are five to eight strong pointed denticles, decreasing somewhat in size laterally. The inner margin of the anterior limb of the base is prolonged slightly as a rounded projection which fits into a depression in the base of the next succeeding tooth immediately below the outermost denticles as if to form an articulation.

Median tooth of 6th row 0.135 mm. wide by 0.156 mm. long. Median tooth of 15th row 0.138 mm. wide by 0.150 mm. long.

Lateral teeth flattened triangular plates terminating in a smooth point, the anterior margin of the base concave, the outer margin curved, its anterior end prolonged farther forward than the inner end, the inner nearly straight; apex pointed and bearing 6 to 12 strong denticles about midway of its length, their points directed obliquely upward. The lateral tooth is somewhat curved downward toward the apex, the tip thus being depressed in a general direction similar to that of the cusp of the median tooth. The median teeth are light amber in color, the laterals pale yellow from the apex down to the region of their lowermost denticles. The seventh lateral measures: outer margin 0.144 mm., base 0.090, inner margin 0.120 mm., height 0.174 mm.; the 15th lateral, outer margin 0.144 mm., base 0.090 mm., inner margin 0.117 mm., height 0.087 mm. Height of apex above denticles 0.036 mm.

In *C. californica* described by Bergh (1904), dredged from the Gulf of California, the radula teeth are in 15 rows instead of 17-18 as in *C. fisheri*; the lateral denticles upon each side of the median spine, as shown in figure 28 of his table 4, are from 13 to 20 in number, instead of 5 to 8 as in *C. fisheri*, and the median teeth are large, being 0.2 mm. long by 0.16 mm. wide as compared with 0.150 mm. long and 0.138 mm. wide in the fifth row of the present species. The lateral plates are described as bearing a finely denticulate inner border, the figure showing 8 to 10.

*Reproductive characters.* Ootestis lobules closely packed behind cardiac regions, each composed of a large central spermiogenic follicle with peripheral ovogenic alveoli opening into it. The hermaphroditic duct, formed by union of branches from each lobule, passes forward above posterior median duct of liver to anterior genital complex. The hermaphroditic ampulla, with a diameter of 0.28 mm., is a cylindrical thin-walled sac coiled in a left-hand spiral at the posterior end of the anterior genital complex, its anterior duct dividing into vas deferens and oviduct. Vas deferens a simple loop, thick-walled and glandular in its prostatic portion, opening into the large cavity of the irregularly folded and conical glans penis, the walls of which are densely glandular. The glans penis is inclosed within the large preputium.

Oviduct short, provided with a small spherical sac opening by a short duct into it beyond which it opens into a ciliated prolongation of the cavity of the nidamental-

albumen glands. The gland-complex duct dilates distally into a crescentic atrial cavity into which opens the slender duct of the elongate bursa copulatrix close behind the opening of the preputium.

*Color.* General ground color everywhere a translucent gray, deepening to pale yellow in the region of the ovotestis and mandibles. The distal half of the anterior tentacles and of rhinophores yellow to cadmium orange, deep in some specimens, in others varying lighter to almost uniform gray. A narrow white line extends from the tip of each anterior tentacle backward along its mid-dorsal surface to its base, thence arching across the head, uniting with its fellow immediately in front of the rhinophores and continuing as a single median line along the notum to the tip of the tail. A similar narrow white line originates on each side below the anterior group of cerata, passes straight backward below the cerata groups, and unites with the median white line behind the last cerata. There is variation in the width of these white lines. The rhinophore stalks between the plates, and the anterior tentacles, are frequently lightly encrusted with pure white.

In lighter specimens, the ceras axis beneath the superficial gray integument is a rich chrome orange, subdued in the basal portion, but deepening distally to a light red sharply set off near the tip from a subterminal cone-shaped zone of cadmium orange which in time gives way to gray at the apex. (Pl. 58, fig. 3.) Darker specimens may have at the base a yellow ochre merging into burnt sienna, and this to indian red below the terminal zone which is the brilliant cadmium yellow. Rarely the entire axis is a deep garnet. (Pl. 58, fig. 5.)

*Dimensions.* Length of large living specimen 26.5 mm., maximum height in cardiac region 3.4 mm. Length of foot 23.0 mm., maximum width of foot 4.0 mm. Length of anterior tentacles 3.7 mm., length of rhinophores 4.7 mm. Preserved specimen has a total length of 19.0 mm., length of foot 16.0 mm., maximum height 7.0 mm., width of body 5 mm., length of anterior tentacle 4 mm., height of rhinophore 3 mm.

*Habitat.* Numerous specimens taken from Point Pinos, Point Cabrillo, Monterey Bay, reef near Waddell Creek, Dillon Beach. Not rare, occurring in most rocky pools of Monterey Bay, most frequently found living upon hydroid colonies of the alga *Gigartina canaliculata* and the fronds of *Macrocystis*.

Egg band deposited on seaweed, spiral, looped alternately up and down in secondary loops. Nidosomes laid free in water, held between body and tail looped to the right.

#### EXTENDED ANATOMICAL DESCRIPTION. (Based on serial sections.)

*Alimentary system.* The posterior salivary glands stain deeply, and are made of cuboidal granular cells. The duct passes through the nerve ring at the side of the oesophagus, penetrates the bulb, and opens into the pharyngeal cavity at the side of the angle of the radula. The anterior salivary glands are branched, tubular; the main duct

is lined with cuboidal cells. This passes toward the median plane from either side of the oral tube, uniting in a median terminal segment which opens in the middle of the lower lip.

In the stomach, sections show ridges in the dorsal wall covered with ciliated cells. The ventral wall is smooth, the cells are high, becoming cuboidal as the liver rami are reached. Two anterior bile ducts from the anterior curvature pass forward to the cerata on either side, while a large median one passes to the posterior groups.

The lateral kidney lobes unite in a broad median portion from which diverticula pass out to the bases of the cerata groups, branching freely in short tips there. The renal pore opens but 0.2 mm. behind the syrinx.

*Reproductive system.* (Pl. 66, fig. 11.) Vas deferens, a narrow thin-walled tube about 0.09 mm. in diameter, immediately dilates into a cylindrical glandular segment, passing directly upward and backward to the proximal end of the muscular preputium and entering the large cavity of the *glans penis*. This is a complicated organ, densely glandular and irregularly folded. The lobe is roughly triangular, with a pointed tip. Toward the opening a second lobe appears; this enlarges and becomes connected with the original mass. The surface is deeply folded, the basement lining consists of a layer of columnar cells, the walls possess long tubular glands. (Pl. 66, figs. 13, 14.)

The everted glans is short, tumid, oval in outline. Its anterior margin is prolonged upward into a pointed claw-like tip directed backward. Immediately behind the tip is the anterior end of the elongated slit-like apical opening of the deferent duct closely lined with large secreting glands.

The histological details of the glandular vas deferens are of special interest. This prostatic segment reaches 0.096 mm. in diameter, the cells of the epithelial lining being 0.036 mm. high, with dense spherical basal nuclei, the distal half crowded with coarse granulations.

The nuclei are large, round, usually basal, containing large chromatin granules. Secretion granules, found in the mid-portion of the cell, seem to be inclosed in vacuoles. Between the granular cells is a series of much smaller oval nuclei in a single row near the free border, wedged in between the glandular ones. As the glandular zone thickens, differentiated tubular glands appear; these are made up of cells similar to the gland cells, just described, but invaginated in groups to form tubular glands. The intermediate ones continue as a surface epithelial layer.

*Comparison.* The two Monterey species of *Coryphella* differ in color and color markings. The white lines on *C. fisheri* are a constant specific mark, seen clearly in the tide pools. The cerata are more slender in *C. pricei*, not inflated, the axial liver branches narrow. The groove on the ventral side of the anterior tentacles of *C. pricei* is not present in *C. fisheri*. There is a marked difference in size of the ampulla and prostate, and the shape and size of the glans penis.

*Coryphella fisheri* is found abundantly; *C. pricei* is relatively rare.

Genus *Eubranchus* FORBES

*Eubranchus* FORBES. 1838. A Catalogue of the Mollusca Inhabiting the Isle of Man and the Neighboring Sea. Malacologia Monensis. p. 5. Genotype (monotypic), *Eubranchus tricolor* Forbes, 1838.

*Body* elongate, arched above, anterior end of foot rounded; tentacles smooth, linear, slender; branchiae in distinct rows, erect, inflated, may have constrictions; mandible masticatory margin with one row of denticles; radula triserial, one lateral, thin, plain plate; penis may bear a chitinous tip.

*Eubranchus occidentalis* MACFARLAND, new species

Plate 62, figure 7; plate 65, figures 19-25; plate 66, figure 7

*Living animal.* Body narrow, high, slender, arched above and generally rounded. Head high between the rhinophores, rounded down to the anterior margin.

*Foot* narrow, linear, with a short, blunt, slightly flattened tail separated from the sides of the body by a marked groove. Anterior end widened and rounded with slightly thickened edges. When floating these are in contact with the water.

*Anterior tentacles* slender, cylindrical, ends blunt, about one-half the length of rhinophores; base at the anterior sides of head; directed outward and backward.

*Rhinophores* long, simple, smooth, not retractile into sheaths, slightly tapering to blunt tips, carried erect, diverging but little.

*Dorsum* bears five to six rows of club-shaped *processes*, three to six in each row, gradating in length from within outward, the outermost often being present only as tubercles directed outward and upward. These *cerata* are very long, prominent, conical at the tips, carried erect at right angles to the body surface; first and second groups opposite, the remainder slightly in advance on the left side of corresponding groups of the right side. Constrictions at the base of the conical tip, above and below the greatest diameter, mark off each ceras into circular thickenings which may bear rounded tubercles in a transverse series, being accentuated by white spots upon them. The *cerata* are readily caducous and quickly regenerated.

*Mouth* a simple slit.

*Reproductive openings* below the lowest ceras of the first group on the right.

*Anus* and *renal* pore slightly posterior.

*Color.* (Pl. 62, fig. 7.) The general body color ranges from delicate gray to light cream or chrome yellow to a soft brown. Each variety has its respective liver colors and surface markings. The deep liver branches vary from yellow-green to brown. The dorsal surface of the body and sides are closely mottled by irregular flecks and



patterns of green, bright to dark. The sides and upper surface of the foot margins are marked by many minute spots of chrome yellow. The surface markings of the dorsum follow closely the main liver branches as a dense encrusting of color, the two main parallel lines following the bases of the cerata and merging on top of the head between the rhinophores.

The individual ceras has a clear conical tip with a white band below, followed by a wide circular band of green and black spots at the narrowed base, thus defining the conical end. Each constricted place has a similar band more or less clearly defined.

The sharply defined axial liver branches repeat the dilations of the cerata with a mass of green or brown color, and, in addition, flecks of green are scattered over the surface.

The rhinophores and anterior tentacles have, below the clear-white end, a sub-terminal band of coppery green, quite metallic in appearance and a constant specific mark. Over the surface are sparsely scattered flecks of color.

The colors used in the painted figure were hooker's green, burnt umber, chrome yellow, and black.

*Internal anatomy.* An elaborate system of salivary glands is present. They surround the posterior end of the buccal masses, communicating with the anterior end of the oral tube by two slender ciliated ducts.

The buccal mass, elliptical in outline, measures .8 mm. long, .45 mm. high, .55 mm. wide.

*Mandibles* (pl. 65, figs. 19, 20) strong, elongate, triangular in form, rather strongly concave. Thickened at the hinge region and along the ventral border. Masticatory wing with strong ridge-like growth lines. Mandibles 0.51 mm. long, greatest width 0.24 mm., mandibular process 0.06 mm. long. Denticles of the masticatory margin in a single row, the upper ones worn away into simple teeth; below, larger ones made up of transverse ridges, each with fine serrulations, numbering from 12 to 20. The highest ones measure about 0.002 mm.

*Radula* (pl. 65, figs. 21-25) slender and tapering to the anterior end which is doubled back rather abruptly at this end of the radula sheath. Teeth triseriate, with a strong median denticular tooth and one flat, thin, smooth lateral on either side, bearing a single, smooth, sharp spine on its median edge.

The median teeth number: 3 incompletely developed, 19 in the sheath, 36 outside the sheath, giving a total of 58. In a second specimen there were 36 mature, 23 in the sheath, 3 incompletely developed, with a total of 62. Median tooth has a central cusp prolonged into a strong hook, tip bent downward, depressed below the three to five smaller lateral denticles borne upon the edge of the lateral slope. In the youngest portion of the radula under the sheath, on the teeth, .547 mm. in length, are borne five denticles. In the used portion, on the teeth, .415 mm. long, three or four lateral denticles occur. The radula length is .962 mm., base with a deep arch, bearing three rounded projections, one at the base of the median cusp, one on either side just posterior to the



central one, all so placed that they fit into depressions of the next succeeding tooth.

Width of youngest laterals, .0747 mm.; length including spine .0249 mm. Vertical height of youngest median teeth .0415 mm.

*Dimensions* of average specimen. Length 9 mm., width over cerata 5 mm., at heart 1 mm., spread of rhinophore 3.5 mm., of anterior tentacle 3 mm., longest cerata 3 mm. Length of foot 7 mm., width 1 mm.

*Habitat.* In open rocky pools of Monterey Bay, most often at Point Pinos, Large Tide Pool; Point Cabrillo on the hydroid colonies of *Hydractinia* which occur on the holdfasts of the alga *Cystoseira osmundacea*.

The spawn is frequently found on the hydroids, a broad, short, thick band of pink color in one and one-third turns.

#### EXTENDED ANATOMICAL DESCRIPTION.

*Liver.* A large bile duct arises from the anterior left curvature of the stomach. From this a branch arches to the right where it divides into anterior and posterior parts, sending its terminations to the first and second groups of cerata on the right side. The larger left duct also divides, sending terminal divisions to the first and second groups of the left side. The main trunk turns right behind the stomach, develops into the median branch, alternately sending a branch to the base of each group which supplies the axial terminations to each ceras of all posterior groups.

The rhythmic pulsations of these branches are clearly seen, first being visible in front of the heart, traveling backward in a wave, 15 contractions per minute.

*Reproductive system.* (Pl. 66, fig. 7.) The anterior genital mass is squarish in outline as seen from above, its ventral and posterior part made up of the thick mucous gland lobes in an L-shaped mass. The anterior face is occupied by the preputium and the ducts, between them and the mucous lobe is the more convoluted albuminous portion.

The nidamental gland complex is relatively simple. Ventrally it passes externally by a duct below the vagina into the vestibule.

Upon leaving the ovotestis, the hermaphroditic duct enlarges into an elongated ampulla which at the narrowed distal end divides into the vas deferens and the oviduct. The latter passes at once into the nidamental gland. The vas deferens continues as a very long narrow duct. The cuboidal cells lining this bear long fine cilia and are surrounded by a thick layer of circular smooth-muscle fibers. External diameter 0.032 mm., lumen 0.016 mm. As it nears the base of the preputium, it thickens into a glandular prostatic portion, is slightly constricted, bends sharply at a right angle, dilates into what appears to be part of the preputium for about half the length of the glans, extending into its body, and then narrows into the vas deferens proper. This first or distal portion is lined by the same type of high glandular epithelium as that of the glans lumen.

The glans is bluntly conical, 0.9 mm. long by 0.15 mm. basal diameter. Its tip bears a short, curved, chitinous tube lined with cells of the vas deferens lumen. Back of the tip, the lining thickens into a columnar glandular epithelium surrounded by muscu-

lar layers. At the base of the glans, the surface epithelium is reflected upon the inner surface of the preputium as a lining, merging at the opening with the external epithelium.

The preputium is directed outward and downward to the external opening. At its proximal end there enters the duct of an accessory pear-shaped gland, thick walled and saccular, the lumen reaching the thickness of its walls in diameter. Its fundus is looped sharply outward parallel with the preputium. The duct of the accessory gland continues down the ventral side of the glans lumen following that of the vas deferens near its tip before opening into it.

The vagina is wide, having at its proximal end a blind sac, the spermatheca. The broad external opening into the vestibulum is just above that of the nidamental gland.

## Family CUTHONIDAE

### Genus *Cuthona* ALDER and HANCOCK

*Cuthona* ALDER and HANCOCK, 1855. Monograph of the British Nudibranch Mollusca, pt. 7, App. p. 22. Genotype, *Eolis nana* Alder and Hancock, 1842. Annals and Magazine of Natural History, vol. 9, p. 36.

Body depressed, head wide, foot wide, rounded in front. Rhinophores simple, smooth, anterior tentacles linear; cerata in closely set rows; anus dorso-lateral.

Margin of mandibular process with a single row of denticles. Radula teeth in a single row, arched, with a prominent central cusp and marginal denticles.

Otocyst with a single otolith. Penis unarmed.

The above generic characters are made up of the original ones of Alder and Hancock to which have been added certain others since shown to be important. Taken as a whole they clearly define the genus. Unfortunately no adequate anatomical study has been made of the genotype, *C. nana* Alder and Hancock, nor of any of the other species of the genus, several of them being known only by the descriptions and figures of Alder and Hancock. Further research must be awaited to settle the position and relationships of most of them.

With the exception of the report of *Cuthona nana* in the Bering Sea (Krause, 1885) no representatives of the genus have been taken previously in east Pacific waters. The addition of the following new species from Monterey Bay, California, is hence of decided interest geographically.

### *Cuthona rosea* MacFARLAND, new species

Plate 59, figures 1, 2; plate 68, figures 1-7; plate 70, figures 9, 10

*Body* but slightly depressed, wide, rounded above, tapering backward to the short pointed tail which is nearly concealed by the overlapping posterior dorsal papillae. Sides of the body clearly set off from the foot margin.

*Foot* widest in front, tapering behind, its anterior margin rounded and thickened.

*Head* broad, the frontal margin wide, crescentic, prolonged backward laterally as a rounded lobe on either side.

*Anterior tentacles* long, tapering, blunt, directed outward, arising from the frontal margin a short distance on either side from the median line, two-thirds to three-fourths as long as the rhinophores.

*Rhinophores* simple, smooth, long, tapering, erect, diverging but slightly, their bases close together, their tips blunt.

*Dorsal papillae* linear, cylindrical, tapering to pointed tips, borne in close, transverse, or slightly oblique dorso-lateral rows, the inner ends of which are well separated in front but approach the mid-dorsal line in the posterior region. The first two to three rows are in front of the bases of the rhinophores and contain three to four papillae, the number increasing to 18 to 20 by the eighth row, thence decreasing to a single papilla in the 18th to 20th row. There are from 35 to 45 cerata in the pre-cardiac rows on each side. The heart lies opposite the sixth and seventh rows, but there is no marked cardiac interval free from papillae, and it is entirely concealed by their overlapping. The papillae are longest at the inner ends of the half-rows, decreasing to very short, or rudimentary, ones at the outer ends. The bases of papillae may become irregular in the longer rows, approximating double, rather than single series.

*Eyes* immediately behind the bases of the rhinophores, showing obscurely through the integument, being practically sessile upon the dorso-lateral sides of the cerebral ganglia.

*Mouth* a longitudinal slit, dilated somewhat at anterior end, its margins inflated, as is the whole ventral surface of the head, and thickly beset with labial glands.

*Anal opening* at summit of tall, prominent, cylindrical papilla in front of the upper inner end of the eighth half-row of dorsal papillae in the dorso-lateral line of the body. Renal pore minute, inconspicuous, immediately in front of the anus.

*Reproductive openings* well forward on right side, immediately behind the level of the bases of the rhinophores between the fourth and fifth rows of cerata. The male opening is at the summit of a low, nearly hemispherical elevation, behind which is a more prominent, slightly curved groove and a thickened elevation forming the posterior boundary of the genital vestibule.

*Mandibles* (pl. 68, figs. 1, 2) small, triangular in general outline, thickest in hinge region. Masticatory process short, 0.27 mm., the margin much worn near the hinge, below bearing a single series of 10 to 14 irregular, stout, blunt denticles.

*Radula* (pl. 68, figs. 3-7) somewhat tapering, uniserial, composed of 28-32 strong hooked teeth, their bases horseshoe-shaped, the cusp strong, nearly erect, triangular, its tip curved backward. Lateral denticles 8-10, strong and pointed in the ma-

ture. posterior part of the radula, decreasing in front to four or five worn and broken remnants.

*Reproductive characters.* Vas deferens moderately long, thickened; the short, conical, unarmed glans penis is located at the base of the short preputial sac which has an accessory penial gland appearing as a prolongation.

Vaginal duct with a wide external opening, receiving in its innermost proximal part the spermatheca; distal to this is the duct of the bursa copulatrix.

*Body color* translucent cream, inclined to pink or very delicate umber. Transparent margins of foot and papilla a clear gray. Axis of each dorsal papilla occupied by a narrow branch of the liver, varying from rose madder to burnt umber in color. Tips of papillae encrusted with pure white which may extend down the papillae as scattered flecks for varying distances. Ootestis lobules show through the integument rose (carmine) pink.

*Dimensions.* Maximum length of living specimen 34.0 mm., length of rhinophores 4.5 mm., length of anterior tentacles 4.0 mm. Average specimen: body length 25 mm., foot length 22 mm., anterior width 3.5 mm., head width 4 mm., rhinophore length 5 mm.

Length of preserved specimen from anterior frontal margin to tip of tail 14.6 mm., length of foot 14.0 mm., width of anterior end of foot 3.2 mm., maximum height of body 4.4 mm., maximum width of body 3.7 mm., maximum width of head 3.5 mm., interval between anterior tentacles 0.8 mm., length of contracted rhinophores 2.0 mm., length of contracted anterior tentacles 1.4 mm.

*Habitat.* Taken in considerable numbers during summer months upon colonies of the pink hydroid, *Hydractinia*, which is common upon the holdfasts of *Cystoseira osmundacea* (Menzies) C. A. Agardh, one of the brown kelps frequently to be found in larger tide pools along the coast from Monterey to Point Pinos and southward. Sometimes found floating on the surface in quiet water.

#### EXTENDED ANATOMICAL DESCRIPTION.

*Alimentary system.* The head disk is richly supplied with simple tubulo-alveolar glands, abundant in the region of the mouth but not extending into it. Similar glands in large numbers open into the sulcus between the anterior end of the foot and the head disk.

The paired ducts of the *anterior salivary glands* open into the oral tube immediately in front of the mandibles. They pass laterally backward along the surface of the bulb to which they are closely attached. They ramify to dense masses of alveoli lying on either side of the posterior end of the bulb in contact behind with the lobules of the posterior salivary glands which lie more dorsally above the posterior border of the bulb and lateral to the stomach.

The paired ducts of the *posterior salivary glands* open through the roof of the bulb, on either side of the oesophagus, and pass back through the nerve collar, rami-

fying into a dense mass of alveolo-tubular end pieces lying above and behind the posterior end of the bulb, and above and lateral to the stomach, the terminal branches reaching back as far as the level of the anal opening. The alveoli of the anterior salivary glands are spherical or pyriform in shape, filled with granules staining with basic dyes, and are readily distinguished from the more elongate and less granular alveoli of the posterior ones.

The very short oesophagus leads directly into the roomy stomach, the anterior portion of which overlies the hinder end of the pharyngeal bulb, and extends laterally nearly the width of the body cavity. Its tapering posterior end is continued as a wide median tube through the whole length of the body between the lateral lobes of the ootestis. It gives off branches to the successive rows of dorsal papillae which terminate in large liver rami filling the axis of each papilla, and at its distal end opening into the oval cnidosac which, in turn, communicates with the exterior by a narrow apical pore.

From the posterior left margin of the stomach a lateral biliary tube arises, passing forward to the precardinal cerata of the left side. Slightly in advance of its origin, on the opposite side, a similar tube is given off below the overlying intestinal diverticulum and passes to the right precardinal groups of cerata.

Within the left side of the dorsal wall of the stomach, a system of a few, low, longitudinal ridges leads back to the opening of the left biliary tube. A similar series on the right side leads into the intestine. The ventral wall has a series leading to the posterior biliary tube. The stomach, its median posterior prolongation, or posterior hepatic and lateral ducts and branches as far as the bases of the papillae, is lined with low ciliated epithelium; the continuation as hepatic tubules in the dorsal papillae is made up of cuboidal glandular epithelium packed with small granules.

From the posterior dorsal wall of the stomach a roomy diverticulum passes to the right and downward, narrowing into the intestine which forms a simple loop almost to the foot, returning to terminate in the anal papilla.

The distal ends of the papillae are occupied by the elliptical cnidosacs, opening proximally into the hepatic tubules and distally opening externally at the apex of the papillae by a minute pore.

In the study of serial sections, cnidocysts were found in the liver diverticulum, not merely in the terminal cnidosac; some are free, resting against the epithelium; others are inclosed in epithelial cells. The cnidocysts are slightly curved, cucumber-shaped, darkened by the stain, and have a very deeply stained central rod-like structure. In the stomach of this same series are numerous cnidocysts, 0.0055 mm. long by 0.00165 mm. wide. (Grosvenor, 1903, *Proc. Roy. Soc. London*, vol. 72, pp. 462-486.)

Each ceras has two main blood channels, an outer and an inner one. The outer seems to be connected with the general system of blood sinuses, the inner to open into the veins leading directly to the auricle. At the base of the ceras, this vessel is supplied with a considerable sphincter muscular development by which extention of the ceras is controlled.

The renal opening is close in front of the anal papilla. Sections show the short



tube, .027 mm. long, opening into a large roomy kidney sac. The renal syrx tube opens from this sac in front of the renal papilla into the pericardium in the extreme right margin as the ventricle begins to show. Width of renal sac 0.465 mm., height 0.12 mm. Length of syrx approximately 0.45 mm. The renal sac assumes a median position behind the pericardial sac, overlying the posterior viscera, and continuing back to end of the body.

Pharyngeal bulb cavity (in addition to mandibles and radula) everywhere lined with a strong cuticula varying in thickness in different portions. Dorsally it extends well into the anterior end of the oesophagus. In front of the mandibles it covers the inner mouth opening and lines the dilated inner end of the mouth tube, thinning away toward the external opening. Covering the inner lip disk, this cuticula becomes resolved into short blunt rodlets, each corresponding to a cuboidal epithelial cell at its base. These are longest near the margin of the inner mouth opening and become shorter toward the periphery of the disk, being especially well developed in the dorso-anterior sector of the latter.

Radula sac 2.0 mm. long, 1.2 mm. transverse diameter, 1.2 mm. high. The teeth are deeply implanted in a thick cuticular basement membrane which unites in the sheath region into a cuticular roof over the teeth. In front of the sheath the cuticle forms a continuous lateral fold on either side, obscuring the lateral view; only at the tip of the angle are the teeth fully exposed. Seven teeth are beyond the angle at the anterior end, six at the angle and back to the sheath, 16 to 19 within the sheath.

Vertical height of oldest .049 mm., of seventh at angle .044 mm. Length of base median line of oldest .035 mm., of seventh at angle .038 mm.

*Reproductive system* (pl. 70, fig. 9). Closely packed follicles of the hermaphroditic gland fill the posterior part of the body, their main duct passing forward in the lower median line just above the posterior liver duct. It opens into the hermaphroditic ampulla wedged in a deep groove upon the posterior dorsal surface of the anterior genital complex, 3.8 mm. long; 2.8 mm. broad; 2.2 mm. thick.

At the anterior end of the ampulla, the short duct divides into the oviduct, passing directly into the fertilization chamber and the vas deferens, which latter becomes thickened and glandular as the prostate and passes into the base of the short and broad preputial sac, 1.7 mm. long.

The glans penis .5 mm. long, arising within the preputium, is a short broad cone without armature of any kind.

At the inner end of the preputium, nearly as wide in diameter and appearing as a prolongation of it, is a simple, elongate, thick-walled tapering gland, the accessory penial gland. Its proximal portion, nearly four times the length of the preputium, describes a loop upon the anterior face of the genital mass and tapers to a blunt upturned tip. Its distal end projects into the base of the glans penis and gives off a short duct which passes outward in the glans, parallel to the duct of the vas deferens, the two merging in the outer fourth of the glans.

The prostatic epithelium is high columnar with basal nuclei, the outer three-fifths of each cell being packed with rather coarse granules becoming finer and fewer in the zone immediately above the nuclei. The accessory gland attains a diameter twice that of the prostatic vas deferens, its epithelium being high and pseudostratified with nuclei at two or three levels; the cells are clear and slightly granular.

The oviduct (pl. 70, fig. 9) passes sharply backward from its origin as a branch from the hermaphroditic duct distal to its ampulla, and passes at once into the fertilization chamber. Close to its entrance appears a slender duct which dilates into an elongate sausage-shaped sac, the spermatheca.

Close behind the external opening of the preputium is the crescentic opening of the female genital vestibule, a broad duct passing obliquely inward. Its epithelium is high and ciliated; the wall is thrown into numerous longitudinal folds, 10 to 16 in number. It receives near its inner end the slender long duct of a small spherical sac, the receptaculum seminis or bursa copulatrix. Near the entrance of this duct is the opening of the duct to the fertilization chamber. Into the latter also open the wide passages to the albumen and mucous glands of the nidamental complex.

*Central nervous system.* (Pl. 70, fig. 10.) Cerebro-pleural ganglia fused completely into a uniform, flattened, ovoid mass with no indication whatever of the line of junction on either side. At the anterior end the two are joined by a very short cerebral commissure. The posterior ends are widely separated. Length of commissure 0.015 mm., width 0.09 mm. Each ganglion forms a nearly equilateral triangle.

From the anterior dorsal margin, the thick short rhinophore nerve, No. 1, passes forward and upward dilating into the large rhinophore ganglion at the base of the rhinophore into which several trunks pass.

A slender nerve, No. 2, arising outside the base of rhinophore nerve No. 1, passes forward to the anterior surface of the head.

The strongest cerebral nerve, No. 3, from the outer antero-lateral margin, passes forward to the dilated region of the head in front of the mouth.

Below and just in front of and behind the eye, two nerves, Nos. 4 and 5, of equal size, pass downward around the pharyngeal bulb to the mouth region.

The 6th nerve from the posterior margin of the cerebro-pleural mass passes backward to the body wall. Outside the base of No. 6 on the right side is a slender nerve, No. 6a, found in one specimen; this passes to the body wall.

Below the posterior end of the cerebro-pleural ganglion on the left and right, median to the origin of No. 6, is a slender nerve, No. 7. Numbers 6 and 7 approach and unite by a short anastomosing branch. They are traced to the dorsal wall of the stomach.

Close in front of the eye, a slender nerve, No. 8, arises, bifurcating at once, probably passing to the integument behind the rhinophore.

The eye is sessile upon a small optic ganglion fused to the cerebral.

The otocyst is sessile close to the dorsal margin of the cerebro-pedal connective. A single otolith is found.

The cerebro-pleural ganglia are united with the pedal by two, short, well developed connectives on either side, the cerebro-pedal and the pleuro-pedal respectively.

Three pedal nerves occur on the left side; Nos. 1 and 3 are strong, between them a more slender one, No. 2, all distributed to the foot.

On the right side beside two strong nerves, Nos. 2 and 3, the strong, broad root of No. 1 on the antero-lateral side, appears to have two roots, the anterior one may come from the pleural ganglion. In a second specimen, three pedal nerves were found on each side.

From the ventral anterior border opposite the eye, the cerebro-buccal connective arises, passing directly to the buccal ganglion.

A slender sub-cerebral commissure follows the anterior border of the pedal commissure, passing in contact with the cerebral border to the cerebral ganglion of each side, entering it near the exit of the pedal connective.

Close to the left pedal ganglion, seen from below, a slender nerve, No. 7, appears from above the pedal commissure, passing to the right side in contact with the ventral wall of the stomach. It follows the gastric curvature up to the right between the lobes of the salivary gland and backward to the dorsal wall of the stomach. It arises from the posterior ventral face of the pleural moiety of the cerebro-pleural ganglia near the exit of the pleuro-pedal connective.

#### Genus *Cratena* BERGH

*Cratena* BERGH, 1864. Danske Vidensk. Selskabs Skr. 5, Raekke Naturvid og Math., Bd. 7, pp. 198, 213.

Note: There is evidence among his notes and a letter from Nils Odhner that the author was carefully evaluating the status of the proper genus name for this group of aeolids prior to his death in 1951. However, the manuscript is published as left by him because he had not seen the later publications. The paper by Winckworth (1941, pp. 146-149) in which *Catriona* is substituted for *Cratena* is especially significant. (O. H. MacF.)

#### *Cratena rutila* MacFARLAND, new species

Plate 60, figure 1; plate 67, figures 1-6a; plate 69, figures 1, 1a; plate 71, figure 21

*Body* limaciform, high in front, not depressed, somewhat compressed, head abruptly rounded from above downward in front, narrower than the body. Anterior head margin not thick but passing back as a thin edge to the anterior foot line. *Foot* narrow, sharply set off from the body by a longitudinal groove, with narrow edges.

*Anterior* end and *angles* of *foot* rounded, narrowing posteriorly into a pointed, slightly flattened, well defined, long, slender *tail*, greatest width 1 mm.

*Anterior tentacles* stout, cylindrical, tips rounded; placed well up on the antero-dorsal margin of the head and inclined outward. Length about one-half to two-thirds that of the rhinophores.

*Rhinophores* long, smooth, gently tapering to blunt tips. Bases merging, the stalk divergent, inclined forward.

*Cerata* large, club-shaped, rounded apices, narrowed at the base, inclined backward, not always recumbent, in eight to nine transverse rows. These are separated into two groups, first of three to five rows in front of heart region; the first row with one to three cerata, increasing in remaining rows to five to eight. Posterior of the heart, the rows are more equally spaced, decreasing in number of cerata as the tail is reached.

*Eyes* immediately back of rhinophores, sessile, resting upon the optic ganglion. *Otocyst* present.

*Mouth* with thickened lips.

*Anal opening* at the summit of a slight dorso-lateral elevation, on a level with the innermost ceras base of the first post-cardiac row. Renal opening 0.13 mm. in front of the anal.

External *reproductive openings* on the right, immediately below the third row of cerata of the pre-cardiac group.

*Mandibles.* (Pl. 67, figs. 5, 6, 6a.) Pharyngeal bulb, 1.4 mm. long, 0.8 mm. wide by 0.8 mm. high. Anterior and ventral edges of the mandibles dark brown, remainder pale yellow, very thin and delicate except at the hinge. The masticatory process is short, its edge becoming a single series of a few rather coarse denticles dying away toward the hinge in obscure serrulations.

*Radula.* (Pl. 67, figs. 1-4.) Uniserial, long in a U-shaped loop, the two limbs about equal in length, 37 teeth from the sheath end to angle of radula, 44 teeth from the angle to the oldest tip, 81 in all. Length of radula about 1.9 mm. In three mounts the average number is 84 teeth. The median tooth with a strong central cusp; six lateral denticles borne upon the sides, decreasing from the center outward. Occasionally a small slender denticle occurs beside the main cusp. This cusp throughout its length is rounded and elevated as a median ridge, the end extending slightly beyond the inner curved margin. Base semicircular in shape, ventral surface convex, with a rounded depression on the lateral face just below the lowermost denticle. Into this depression, a posterior rounded projection on the inner border fits, forming an articulation.

*Reproductive system.* (Pl. 69, figs. 1, 1a.) The narrow hermaphroditic duct dilates into the ampulla which lies in a close simple coil upon the upper inner face of the adnexed genital mass. After the division into the oviduct and vas deferens, the latter continues as a very slender tube its entire length, entering the basal end of the preputium, a short wide sac in which the glans penis is inclosed.

This is cylindro-conical in shape, the distal end being abruptly rounded and terminated by a chitinous tubular prolongation of its canal which narrows to a small opening. This tube appears to extend beneath the epithelium at the tip rather than above it as would be expected. It does not extend into the canal. (Pl. 69, fig. 1a.) Total length in a straight line .0825 mm., length of exposed part .0247 mm., length of chitinous wall under epithelium .0385 mm., in diameter at opening .0137 mm.

At the proximal end of the penis lies an ellipsoidal, thick-walled, glandular sac opening into the duct of the vas deferens by an extremely short duct. This glandular sac evidently secretes a fluid similar to that of the glandular prostate segment in other nudibranchs, being a modification in the wall of the vas deferens itself. Glans penis length 0.3 mm., maximum diameter .165 mm.

The vagina runs straight outward, then backward on the dorso-anterior face of the mass and terminates by a narrow duct in a small sac which lies parallel with its proximal end. There is no trace of the vaginal duct with it.

*Color.* General body color a translucent gray-white, inclined to cream, the ovotestis showing through the integument as a pale-yellow mass. A large red-orange, rhomboidal-shaped spot covers the top of the head; a similar color entirely covers the rhinophores and the tips of the cerata. This terminal spot of the cerata coincides with the cnidosacs and lies under the surface, while a streak of vermilion follows the translucent edges. These liver branches are ochre in color, narrowed at the base, widening and becoming dark brown as the tips are reached. While these branches apparently fill the cerata, the margins are clear gray. Encrustations of white are always present on the median line of the tail and over the distal two-thirds of anterior tentacles.

*Dimensions.* An average specimen was 12 mm. long, 2 mm. wide, with rhinophores 2.5 mm. high, anterior tentacles 1.3 mm., cerata 1 mm. in length. This is a very small aeolid, ranging in length from 5 to 14 mm.

*Habitat.* Not rare, collected in the tide pools of Monterey Bay from Point Pinos to Point Cabrillo. Found on finer textured algae or floating on the surface of a quiet pool.

#### EXTENDED ANATOMICAL DESCRIPTION.

*Glands.* The lips and anterior foot region very glandular, with thickly set unicellular elongated glands.

Pre-bulbar glands open by a very short median duct in front of the pharynx through the floor of the oral tube. The duct divides into right and left branches which pass backward along the lower body wall ramifying to the lobules of the gland which are especially abundant above, lateral to and below the pharyngeal bulb, and in grape-like clusters lateral to and below the viscera, to the posterior third of the body. The cells are acidophil, spherical; communication is by a narrow neck with the duct.

The post-bulbar glands are large and extensive.



The renal syrinx has a simple wall, the duct opening into the pericardium and then to the kidney.

*Central nervous system.* (Pl. 71, fig. 21.) The cerebral and pleural ganglia of each side are fused into an ovoid mass, slightly flattened dorso-ventrally and with no distinct indication of their plane of union. The broader end of the mass is directed forward, the inner faces of the right and left moieties being appressed in the median plane and united at the anterior, cerebral end by a strong rounded commissure. They are also united below the oesophagus by a very slender suboesophageal-cerebral commissure which passes close in front of the pedal commissure. A very slender pleural commissure forms a loop below the oesophagus behind the pedal commissures and passes upward and forward along the inner faces of the pedal ganglia to unite on either side with the pleural portion of the cerebro-pleural ganglion. From this pleural commissure a median nerve is given off slightly to the right of its mid-point, passing to the anterior reproductive complex. In an average individual, the cerebro-pleural ganglia measure 0.21 mm. in length by 0.18 mm. in maximum horizontal diameter.

Immediately behind and below the cerebro-pleural ganglia are the pedal ganglia. They are nearly spherical in form, 0.18 mm. in diameter, and are united to the cerebro-pleural ganglia by very short cerebro-pedal and pleuro-pedal connectives. Below the oesophagus, they are united by a relatively long and strong pedal commissure, and by a more slender parapedal commissure just behind it.

Immediately above the cerebral commissures, appears a single median nerve which passes forward in the median line to the integument of the mid-head region. Its exact origin has not been determined satisfactorily, but it appears to receive fibers from each cerebral ganglion, immediately above the origin of the cerebral commissure.

From the anterior upper face of each cerebro-pleural ganglion is given off a stout nerve, No. 1, which swells promptly into a rounded ganglion from which a number of strong branches pass to the rhinophores.

Lateral to and below the nerves to the rhinophores, the second cerebral nerve arises, and behind it a very strong trunk, the third cerebral, is given off. Numerous nerve cells at the base of this nerve dilate it into almost a distinct ganglion root. The second and third nerves course around the pharyngeal bulb to the anterior tentacles and the mouth region, as does also a more slender fourth nerve, arising just behind the third from the lateral face of the cerebral portion. The fourth passes forward and upward and is distributed to the anterior integument of the head regions. Close to its origin another nerve, the fifth, arises and passes outward and upward with a similar distribution.

The eyes are sessile, resting upon the optic ganglion on the postero-lateral face of the cerebro-pleural ganglion in the angle between it and the pedal ganglion. The lens is exceptionally large. The optic ganglion is likewise sessile, being directly in contact with the cerebro-pleural mass from which nerve fibers are received, as shown in transparent preparations and sections.

Immediately behind the eye is the spherical statocyst nearly one-half the diameter of the former organ. It contains a single large statolith.

Four nerves are given off from each pedal ganglion, *p2*, *p3*, and *p4*, from the antero-lateral, and one, *p1*, from the postero-lateral face. They are all distributed to the foot region.

From the ventro-lateral face of the cerebro-pleural ganglia the cerebro-buccal connectives pass downward and backward to the buccal ganglia, an ovoid pair connected by a short commissure near their posterior ends and lying below the oesophagus upon the dorsal face of the pharyngeal bulb.

From the posterior end of each ganglion, a strong nerve is given off to the oesophageal wall.

***Cratena flavovulta* MacFarland, new species**

Plate 60, figure 2; plate 67, figures 7, 12; plate 69, figures 2, 2a

*Body* limaciform, dorsum rounded above, passing into sides without a ridge or boundary.

*Foot* not narrow, margin extending beyond sides, set off by a groove; anterior angles rounded, somewhat dilated in front above which the first row of cerata arise.

*Tail* rather short and blunt.

*Anterior tentacles* cylindrical, blunt, two-thirds the length of the rhinophores, directed outward and downward.

*Rhinophores* long, smooth, tapering to a blunt tip, diverging outward, slightly forward and seeming to arise from a common base.

*Cerata* plump, inflated, borne on dorsum in nine or more transverse rows extending well down on the sides, short ones near the foot groove, longest on inner end of row, well up on the dorsum; carried erect. The pre-cardiac rows, four and five, close together in one group with two, four, five, six, or more cerata in the individual rows. Post-cardiac rows more distinctly spaced with five, five, four, three, two, one cerata.

*Eyes* black, lateral to and slightly back of the rhinophores.

*Anus* inconspicuous in front of base of innermost ceras of the first post-cardiac row on the right side. Renal pore slightly in front.

*Reproductive openings* on right below the second row of the anterior group of cerata.

*Mouth* an opening with inflated lips.

*Mandibles*. Pharyngeal bulb 1 mm. long, .7 mm. wide, by .7 mm. high. Mandibles pale amber in thin portions, deepening at the hinge region. Masticatory process short, with a single row of slightly rounded denticles.

*Radula*. (Pl. 67, figs. 7, 12.) Uniserial, long U-shaped, limbs nearly equal; 37 teeth to the middle of the angle, 30 to anterior end, 3 loose teeth, 70 in all. Median

spine prominent, standing well above the laterals, the inner end enlarged with a rounded knob below the inner margin of the curve. Sides bearing seven denticles, the central ones as long as the median. The posterior of the inner rounded border has a knob-like extension fitting into a corresponding depression in the tooth immediately in front.

The oldest teeth measure .0605 mm. wide, .0522 mm. long; youngest .0652 mm. wide, .055 mm. long; in side view, base to tip of median cusp .0387 mm. high.

*Reproductive characters.* (Pl. 69, figs. 2, 2a.) Specimen dissected, 3.4 mm. long, notes then made follow. Hermaphroditic duct expands into a very large ampulla lying in a loop upon the inner posterior face of the adnexed genital mass. From its narrowed distal end, the vas deferens increases slightly in size for two-thirds its length, becoming narrowed as the preputium is reached. The glans penis is much contracted in the preputial sac, but when straight is long and slender, terminating in a chitinous tip; length of this tube .0247 mm., diameter .00825 mm.

An accessory gland is long and finger-like, lying above the vaginal duct. It is longer than the preputium into which it passes by a very short duct. This sac is .45 mm. long by .135 mm. maximum diameter, its duct uniting with that of the vas deferens near the base of the glans penis.

Vaginal duct is long, near its distal end it receives the duct of a blind irregular-shaped sac.

*Color.* General body color cream with the ovotestis showing through the integument a deeper shade. A light orange, inclined to red, covers the front of the head extending up the rhinophores one-fourth their length, the remainder being encrusted with pure white. The same white is found upon the distal two-thirds of the anterior tentacles with the orange at the base; also a dorsal median line of white upon the tail. The terminal liver branches well fill the cerata from base to tips with brown irregular lobules. The terminal tips are a deep cream, clearly defined as a cone-shaped mass. Along the clear edges of the cerata is found a clear line of orange. On the surface above the liver are many flecks of cream white. Wide margins of foot thin and translucent.

*Dimensions.* A very small aeolid, ranging from 3 mm. to 10 mm. in length.

*Habitat.* Tide pools of inner Monterey Bay. Not abundant.

### *Cratena fulgens* MacFarland, new species

Plate 60, figure 3; plate 67, figures 8-11; plate 69, figures 3, 3a

*Body* elongate, slender, rounded above, tapering behind to the tip of the rather short tail. It is highest in the cardiac region, sloping gently backward. In front of the rhinophores the head slopes abruptly downward to the anterior margin. The *foot* is broadest in front, slightly wider than the body, the anterior margin somewhat thickened, its outer angles rounded. The sides of the body are distinctly set off from the thin foot margin through the most of their extent.

The *rhinophores* are simple, smooth, tapering to blunt tips. Their bases are near

together, the stalks divergent and directed slightly forward from the erect position. In length, when fully extended, they may attain one-fourth of the total body length.

The cylindrical, blunt, *oral tentacles*, two-thirds as long as the rhinophores, are situated at the outer angles of the head, nearly horizontal, slightly recurved backward. The frontal margin between them is smooth and convex.

The *cerata* are long, cylindrical, tapering distally to blunted tips. They are arranged in from six to eight transverse rows, the number in each half row ranging from one to seven. Three of these rows are pre-cardiac, the most anterior one well behind the rhinophores on the dorso-lateral portion of the body. The post-cardiac rows are more distinctly separated from each other, and, while the innermost cerata of each lateral half row tend to approach each other, they leave throughout a narrow median part of the dorsum free. The longest ceras in each group is normally nearest the median line of the dorsum, those lateral to it being successively shorter, the outermost frequently being scarcely more than a rudiment.

The *eyes* show through the integument as minute black spots, immediately behind the bases of the rhinophores.

The *mouth opening* is a short longitudinal slit surrounded by a thickened lip margin.

The inconspicuous *anal opening* is dorso-lateral, close in front at the inner end of the first post-cardiac group. Immediately in front of it is the smaller renal pore.

*Reproductive openings* on right side, below the first and second rows of cerata.

*Mandibles*. (Pl. 67, figs. 9, 11, *a*.) Triangular in form, the angles rounded, strongly convex in anterior portion, flattened posteriorly. Thin and delicate, pale yellow except in the region of the hinge and masticatory process. Total length 0.62 mm., total width 0.35 mm. Masticatory process short, forming a triangular extension from the anterior lower end of the mandible; its cutting margin is short and bears a single row of small angular denticles, 21 in number, on the free masticatory edge, decreasing in size to mere points as the hinge is approached.

*Radula*. (Pl. 67, fig. 8.) Uniserial, the two portions nearly equal in length; the used having 32 teeth, unused 27 teeth, a total of 59 rows of teeth. Total length of mounted radula 1.072 mm.

The median tooth, with a strong cusp at slightly different level than the five lateral denticles borne upon its sides, forms almost a pectinate tooth. The median cusp, throughout its length, elevated slightly as a median ridge across the arched tooth; the lateral denticles are almost as strong but lie at a lower level. Seen from above, the median cusp is shorter and broader than the denticles. The small denticle next the median cusp alternates on the right and left sides throughout the radula. The figures, not being of successive teeth, do not show this.

A posterior rounded prolongation of the inner border of the lateral basal part of each tooth articulates with a similarly shaped depression on its ventral face in the tooth immediately in front.

*Measurements.*

<i>Tooth</i>	<i>Width</i>	<i>Length</i>
1st	.049 mm.	.0438 mm.
31st	.066 mm.	.060 mm.
52nd	.072 mm.	.063 mm.

*Reproductive characters.* Very large ampulla, long vas deferens. Accessory gland entering the glans penis, its long duct looped about the duct of the vas deferens, joining it at the distal end of the glans. The tip is terminated by a chitinous tube. Spermatheca connects with the vagina by a very long duct.

*Color.* The general body color is everywhere a pale cream becoming a light yellow above the ovotestis and viscera. Thin edges are a clear translucent gray. The liver branches, occupying the central area of each cerata under the integument, vary from a yellow brown, raw umber, to a dark rich brown. At the base and extremity of this brown mass is a pronounced band of lemon yellow. The outer one-fourth of the cerata is white with a conical center, pale yellow definitely set off the cnidosac, edges clear. Over all, on the surface, are definite spots of an encrusting of pure white. The distal halves of the rhinophores and anterior tentacles are similarly marked with white. The median line of the tail may show flecks of white.

*Dimensions.* A large specimen, crawling freely, seldom exceeds 6.0 mm. in length; measurements of specimen painted: length 5 mm., width .5 mm., anterior end of foot width .8 mm., rhinophore and longest cerata 1 mm. long, spread of rhinophore tips 3.3 mm.

*Habitat.* Tide pools of Monterey Bay, most frequently found at Point Pinos, on delicate algae or floating. Rare.

EXTENDED ANATOMICAL DESCRIPTION.

*Alimentary system.* Oesophagus short; stomach roomy, thin-walled, from which two antero-lateral, and one median posterior hepatic ducts arise and ramify to the branches of the liver extending into the cerata. From the lower posterior border, the intestine arises and passes in a loop below the heart to its external opening. A ventral caecum, longitudinally ridged, is found near the entrance of the oesophagus.

A thick mass of glands surrounds the oral tube.

Pre-bulbar glands are extensive along the sides, almost to the end of the body cavity; the ducts opening into the ventral mouth cavity. These glands are made up of two distinct cell types. The larger acidophil cells, with very large nucleoli, seem grouped on the terminal branches of the ducts, the basophil smaller ones along the cuboidal



cells of duct walls. The lumen seems to undulate owing to dilatations at the entrance of the cell ducts.

*Reproductive system.* (Pl. 69, figs. 3, 3a. A composite from camera-lucida drawings.) The anterior genital complex, less than 2 mm. in length, lies obliquely beneath and in front of the stomach. The hermaphroditic duct, arising from the union of numerous branches of the ovotestis lobes, passes forward to the median dorsal surface where it dilates into the U-shaped ampulla which constitutes half of the bulk of the mass. Resting against its anterior face are the loops of the nidamental and albumen glands. The narrow duct from the anterior end of the ampulla divides at once into the vas deferens and oviduct. The former loops to the left and returns beneath the penis sac to its mid-outer face entering through its wall.

This sac includes the preputium proper and an elongate ovoid glandular structure opening into the base of the penis. The penis is conical, tapering to a blunted tip, 0.55 mm. long, basal diameter 0.165 mm. Walls muscular below the cuboidal non-ciliated epithelium. From the opening projects a slender conical chitinous tube, at its emergence short and delicate, the embedded portion cone-shaped below the outer epithelium.

An adnexed glandular sac, simple, elongate, thick-walled, lies at the base. It is almost circular in cross section, the distal one-fourth of its length extends into the base of the penis, the remaining part projecting across the body behind the pharyngeal bulb. Length .42 mm., diameter .143 mm., wall .0178 mm. thick and of strongly developed connective tissue and smooth muscle fibers. The slender duct of the vas deferens is pushed forward by the end of the glandular sac. The two ducts are closely wound in loops, that of the gland being twice the diameter of the vas deferens. In the distal fourth of the penis sac the two unite, that of the gland opening into the vas deferens. Each duct has a lining of cuboidal epithelium.

Immediately behind the opening of the penis sac is a larger opening, that of the vagina vestibulum. Into its distal portion opens a slender duct from the narrow pyriform sac, the spermatheca. Distal from the opening, the duct dilates, describing a double loop, and lying upon the face of the adnexed genital mass.

#### *Cratena albocrusta* MacFarland, new species

Plate 61, figures 1-4; plate 67, figures 13-22; plate 69, figures 4-5a

*Body* slender, high, rounded above, not compressed nor depressed, tapering posteriorly and dying away to a low ridge in the tail region, separated from the foot by a well defined longitudinal groove.

*Foot* wider than the body, widest at anterior end, its margin in front rounded and somewhat thickened, not bilabiate, its thin edges extending well beyond the body, one-half of the width of the latter at the anterior region. *Tail* short, flattened, tapering to a pointed tip, nearly or entirely concealed by the overlapping cerata.

Anterior margin of head convex, bearing at outer angles a pair of widely separated, smooth, cylindrical, bluntly pointed *anterior tentacles*, directed horizontally forward and outward, slightly more than one-half the length of the rhinophores.

*Rhinophores* simple, long, slender, gently tapering, the tips blunt, their bases close together, carried nearly erect or inclined slightly forward, diverging outwardly.

*Cerata* inflated, spindle shaped, tips acuminate, occasionally very slightly flattened antero-posteriorly, arranged in lateral transverse rows, six to seven, the first row well behind the bases of the rhinophores, two to three rows in front of the cardiac elevation, four to five rows behind it. The number in each half row varies from one to five, the largest cerata are nearest the dorsum in each row, the succeeding ones decreasing in dimensions. The post-cardiac cerata are the largest of all. Each ceras is oblique at its origin, all being carried in a horizontal position directed backward and overlapping, only being erected for a moment when the animal is disturbed, non-caducous.

*Eyes* minute, below the integument immediately behind the rhinophore bases. One large otolith found in serial sections.

*Mouth* surrounded by a thickened glandular lip border.

*Reproductive openings* close together, inconspicuous, on right side between rhinophores and first row of cerata.

*Anal opening* on right dorso-lateral margin, immediately in front of the innermost ceras of the first post-cardiac group.

*Renal pore* close in front of anus.

*Color.* (Pl. 61, figs. 1-4.) Ground color of body a clear translucent gray, its dorsal surface encrusted with dead white throughout its full width as far back as the hindmost row of cerata, beyond that point, absent or extending as a narrow and broken median line to the tip of the tail. Laterally the white incrustation is continued downward between the cerata rows for a short distance, the sides of the body being flecked irregularly with white. These tend to fuse, in front, into a line or band, which becomes continuous and wider on the sides of the head below the rhinophores, and is prolonged in front of them to unite with the dorsal area.

*Rhinophores* translucent gray with a slight tinge of yellow, the outer one-third frosted with silvery white. Anterior tentacles translucent gray, similarly shaded with yellow and frosted with white toward the tips.

*Cerata* contain broad glandular diverticula of the liver which nearly fill each ceras, save the marginal area and tips. Two color varieties of the species were found; one with the liver branches ranging from pale to deep green (terre-vert to forest green) the second from pale to deep raw umber. In all color varieties, the cerata tips are more translucent, the outer two-thirds of the cerata are frosted with silvery white, the posterior

ones more completely so than the anterior ones, the tips free from the incrustation, the cnidosacs clearly seen as conical bodies.

*Mandibles.* The mandibles are delicate, elongate, ovoidal in outline, somewhat convex, broadest at the anterior end which is slightly thickened. The simple, small, oval hinge is on the anterior margin, slightly nearer the ventral border than the dorsal one. The triangular masticatory process bears a single series of some 18 coarse triangular denticles, the largest of which reach a height of 0.0033 mm. in a mandible 0.72 mm. in length by 0.36 mm. in width, from a specimen of 4.7 mm. length of body.

*Radula.* (Pl. 67, figs. 13-16.) The lingual ribbon is long and narrow, bent sharply backward at the anterior angle. The teeth are arranged in a single row, being 56 to 70 in number. The oldest end of the radula, as shown in celloidin serial sections, tends to be preserved in a blind pocket in which it is coiled in a manner similar to that in the *Sacoglossa*. This is not shown in the radulae of the other cratenas here described, forms related to this one from Monterey Bay. Each tooth is horseshoe-shaped in general outline, as seen from above. The median cusp is strongly developed and is raised well above the level of the adjacent lateral denticles. The lateral denticles number four or five and are pointed and strong. On the posterior external face of the base of each tooth is a well marked pocket-like depression into which articulates a rounded process borne on the inner anterior face of the base of the preceding tooth. In dimensions the change is not great in passing from the oldest to the youngest portion of the radula. The length of the first or oldest tooth preserved in the radula of a mature specimen was .034 mm., its width 0.0275 mm., while in the 48th tooth, the measurements had increased to 0.044 mm. in length and 0.033 mm. in width.

*Reproductive characters.* (Pl. 69, figs. 4-5a.) Opening of glans penis armed with a delicate, curved, chitinous tube, the prostatic segment of the vas deferens, forming one-half of its length, is thick and cylindrical. Accessory gland of the penis elongated pyriform, its duct extending into the preputium and joining the vas deferens near its tip. The spermatheca joins the vestibulum near the external opening by a wide duct.

*Dimensions.* Length of largest specimen taken 12 mm., width 1.3 mm., length of tail 4 mm.

*Habitat.* Taken upon hydroids in tide pools at Pacific Grove, California; also upon hydroids scraped from the bottoms of fishing barges and boats in the same region (Monterey Bay). Not common.

#### EXTENDED ANATOMICAL DESCRIPTION.

*Alimentary system.* (Pl. 67, figs. 19-22.) Immediately surrounding the oral tube is a thick mass of closely set circumoral glands. The smaller of these are unicellular, the body being located well below the epithelium through which it opens by a long, slender, duct-like prolongation. These are similar to the general type of mucous glands found throughout the full extent of the foot. They open upon the surface of the lip disk

around its full extent. Upon the ventral side of the lip disk, and in the groove between it and the foot, are much longer simple multicellular glands. Each of these is made up of a simple tube of cells, the proximal end thickened into a pyriform shape, the remainder continued as a slender duct to the surface of the epithelium. Duct and dilated end both stain deeply with hematoxylin similarly to the mucous glands, and their secretion is probably similar.

The longest of these glands, as seen in sagittal sections of a 4.7 mm. specimen, measured 0.39 mm., the length of the thickened pyriform end 0.072, its maximum diameter 0.036 mm. The lumen is very narrow and approximately uniform throughout. The diameter of the duct portion was 0.012 mm.

Through the floor of the short oral tube, immediately in front of the pharyngeal bulb, in the median line, opens the duct of the *pre-bulbar salivary glands*. It passes backward in the ventral wall of the tube for about 0.12 mm., then forks into right and left branches which emerge from the tube wall and pass backward and upward along the ventro-lateral surface of the bulb in close contact with the infra-bulbar blood vessel. About the level of the cerebral ganglia each passes upward, branches a number of times, and becomes beset by closely grouped large spherical cells, each one of which opens through the epithelium of the duct by a slender prolongation. These cells are frequently binucleate, and in groups of two hemispherical cells, mutually flattened together against each other and communicating with the duct by a common prolongation. The gland cells are finely granular, the large nucleus contains a well developed reticulum of chromatin granules, and a very large nucleolus with a perinucleolar zone of chromatin granules.

The main ramifications of this pre-bulbar gland lie lateral to and above the posterior end of the pharyngeal bulb. A second mass of endings is found immediately behind the adnexed genital mass, between it and the anterior lobes of the ovotestis. Each gland cell is surrounded by a delicate membrane showing flattened nuclei at intervals. In a great many cases, especially in the more anterior portions of the gland, there are two cells in each group, rarely three. In other cases, the single cell is binucleate.

The ducts of the *post-bulbar salivary glands* emerge from the bulb on either side of the oesophagus and pass backward in contact with the oesophagus through the nerve ring, breaking up into a small number of slightly branched glandular terminations. These are in close contact with, but entirely independent of, the grape-like alveoli of the pre-bulbar salivary gland. The terminations are short, tubular, made up of large cells distended with secretion vacuoles, with denser similar cells crowded between them and evidently representing a different share of secretion.

The posterior salivary glands appear to be entirely mucus in their secretion. The quite slender duct is made up of a single layer of low cuboidal epithelia. At intervals the epithelium may be locally increased in height and transformed into mucus-secreting cells, either entirely surrounding the lumen or on one side only, in which case the lumen takes up an excentric position.

The duct of the *anterior salivary gland* is wider than the *posterior* one, ramifies freely lateral to and behind the pharyngeal bulb, and bears a great number of closely set hemispherical gland cells in groups of two, with their flattened faces in contact. Each is packed full of fine granules which stain pink with eosin. Frequently masses of these granules are found in the lumen where they probably form an albuminous fluid. Each cell contains a large nucleus, containing a very large nucleolus and numerous fine chromatin granules.

Oesophagus short, straight, lined with one layer of cuboidal ciliated cells; it passes directly backward and opens into the dilated stomach just behind the nerve ganglion ring.

Stomach roomy, lined with low ciliated cells; its wall is thin. From its anterior end, behind the origin of the third group of cerata, the stomach gives off laterally on either side a narrow tube lined with cuboidal glandular cells which pass forward, branching to the three anterior cerata rows and to the fourth also by a short branch. The stomach narrows posteriorly into the intestine on the right side and into a median tube which passes backward almost the full length of the body, giving off lateral branches to each group of cerata in succession. The intestine wall develops at once a strong typhlosole, infolding from its dorsal wall. This is almost a complete circle in section made up of elongated, clear, wedge-shaped cells with long cilia twice as long as the other cells.

The kidney is a simple sac, its anterior end below the ventricle region. The syrinx is .51 mm. behind the anterior end. The external pore is 0.07 mm. behind the syrinx. The posterior end of the kidney extends to the bases of the last cerata rows.

*Reproductive system.* (Pl. 69, fig. 4.) The glans penis is broadly conical, with a blunt tip 0.2925 mm. long, 0.12 mm. diameter near the base. Its tip bears a delicate transparent tubular curved stylet, 0.045 mm. long, 0.015 mm. diameter at its base; at the tip reduced to 0.006 mm. The tube is a prolongation of a sub-epithelial portion underlying the epithelium of the tip. It apparently is a product of a basal secretion of the epithelium. Into this tube opens the distal end of the vas deferens, a slender tube entering the basal end of the glans. Close to the tip it also receives the duct of the *accessory gland*.

The surface of the glans is covered with ciliated epithelium. The lining of the preputium is also ciliated, the cilia being especially long in the outer half of the organ, equal to the height of the cells bearing them (pl. 69, fig. 5a).

### *Cratena virens* MacFarland, new species

Plate 61, figure 5; plate 68, figures 8-11; plate 70, figures 6-8

*Body* slender, graceful, narrow, rounded above, somewhat depressed, tapering behind to a rather short, pointed tail. Sides of body set off from the margins of the foot by a shallow groove.

*Foot* narrow, rounded in front.



*Head* rounded, rapidly sloping to anterior margin, scarcely wider than the body.

*Anterior tentacles* nearly cylindrical, tapering very slightly to blunt tips, in life 1.0 mm. long, directed forward and outward.

*Rhinophores* sub-cylindrical, smooth, the tips rounded, the bases close together, in life having a nearly erect, slightly divergent and inclined forward position; total length 1.5 mm.

*Cerata* spindle-shaped, stout, slightly inflated, rounded, tapering to pointed tips, in life directed obliquely backward. Cerata arranged in transverse rows on the dorso-lateral sides of the body, the longest cerata occupying the inner ends of the rows and decreasing regularly in size. The pre-cardiac group is composed of three rows of one, two, and four cerata close together on either side, the first row well back of the bases of the rhinophores. Behind the scarcely elevated cardiac region on either side are four, nearly opposite, transverse rows of cerata, which regularly decrease in number from four to one toward the tail region. The mid-dorsal area of the body is left as a narrow free zone between the innermost cerata throughout all the rows.

*Eyes* visible immediately behind the rhinophore bases as deeply imbedded black points sessile upon the cerebral ganglion.

The *mouth* is a short longitudinal slit surrounded by rather thick lips on the ventral side of the head.

The dorso-lateral *anal opening* is just in front of the innermost ceras of the first post-cardiac group on the right side. Close in front of it is the minute *renal pore*.

The inconspicuous *reproductive openings* are close below, the second row of pre-cardiac cerata on the right side.

General *ground color* of the body is a pale, translucent gray, becoming slightly tinged with yellow around and behind the bases of the rhinophores. The anterior frontal margin between the tentacles is vaguely bordered with light yellow.

*Anterior tentacles* translucent gray, the outer half of each incrustated with minute pure white dots.

Rhinophores translucent gray, pale yellow in the basal half, the distal half of a paler tone and incrustated with minute white dots similar to the tentacles.

Cerata axial liver branches grass green (hooker's) modified with brown, filling nearly the whole organ; the cnidosacs at the tips show as definite cones of orange-yellow, becoming lighter toward the surface. Occasional small superficial flecks of orange or yellow are noted upon the green of the ceras body toward its distal part.

Foot and sides of body of general translucent gray ground color.

*Mandibles* (pl. 68, figs. 8, 9). In the living specimen the outline of the yellowish mandibles is clearly seen through the integument of the head, the hinge being just in front of the base of the rhinophores. The mandibles are thin and delicate, being but

slightly thickened in the anterior portion. The short masticatory margin was broken into several fragments in dissecting it out, so that the exact number of the triangular denticles was not determined, but is probably small. The largest of the denticles measured 0.0027 mm. in height (pl. 68, figs. 8, 9).

*Radula.* (Pl. 68, figs. 10, 11.) The total length of the narrow radula in the single specimen is 0.675 mm., this length being nearly equally divided between the portions in front of and behind the angle. The teeth are 46 in number in a single row, their dimensions increasing but slightly from the oldest to the youngest. Each is of a horseshoe form as seen from above, the lateral basal prolongations rising and thickening toward the mid-line and bearing a strongly developed median pointed cusp. Lateral to the cusp are four to six strong pointed denticles. The anterior end of each lateral prolongation of the base articulates with the preceding tooth by a small-rounded knob on its upper inner border, fitting into a relatively large hemispherical socket at the posterior end of the side of the base. The tooth at the angle (the 23d of the whole series) measures 0.03 mm. in basal length by 0.015 mm. in vertical height from base line to top of median cusp. In the eighth tooth, the corresponding measurements are 0.026 mm. and 0.011 mm., while in the 43rd, one of the youngest teeth, they are 0.027 mm. and 0.017 mm. respectively.

*Dimensions.* The single specimen measured 5.0 mm. in total length; width .5 mm., rhinophores 1.5 mm. long, anterior tentacles 1 mm. long. It was active in the aquarium where it was kept under observation for several days.

*Habitat.* The single specimen of this species thus far found was taken in June, 1905, at low tide, floating at the surface of a pool well out near the limits of the laminarian zone at Point Pinos. Despite careful repeated searching no other specimens have been taken.

#### EXTENDED ANATOMICAL DESCRIPTION.

*Alimentary system.* Fragments of the internal bulbar muscle showed that it was made up of distinctly cross-striated fibers, instead of smooth ones as usual.

The lip region is thickly beset with short tubular glands, as is also the anterior portion of the foot. Anterior and posterior salivary glands are present, their ramifications extending back nearly the full length of the body cavity and almost completely concealing the lobes of the ovotestis and the branching liver tubes. Owing to the lack of material for sections, it was impossible to determine the relative extent of the two glands. The acini for the most part seemed to be made up of a single large spherical cell.

The saccular stomach lies immediately behind and slightly overlapping the pharyngeal bulb. Laterally it gives off tubular branches which at once divide into three rami supplying the three pre-cardiac rows of cerata. From its posterior side, slightly to the left of the central line, a roomy median posterior branch is given off, sending to either side, branches to the successive rows of the post-cardiac cerata.

The branches just indicated are all thin walled. On entering the cerata, their final subdivisions develop a cuboidal to columnar granular epithelium as the glandular

tubules of the liver. Each branch dilates and its outline becomes sacculated, nearly filling the ceras. At the distal end of the latter, the liver branch narrows suddenly and opens by a narrow pore through the cnidophore sac to the external opening.

From the right ventral surface, a roomy pouch-like diverticulum is given off, and from the posterior right upper margin the more slender intestine arises, curving outward and downward in a sharp U-shaped loop close beneath the integument, returning to terminate in the anus immediately in front of the innermost ceras of the first post-cardiac row of the right side. The inner dorso-lateral wall of the intestine bears a well developed typhlosole fold throughout nearly its whole extent.

*Reproductive system.* (Pl. 70, figs. 6, 7, 8.) The central acini of the ovotestis are filled with developing and mature spermatozoa; peripheral to these are numerous origeron acini. The hermaphroditic duct, receiving numerous branches, passes to the genital complex and dilates into the ampulla, partly concealed by the mucous gland. From the slender anterior end the vas deferens is given off, and it doubles sharply back upon itself to open into the lumen of the nidamental gland as the oviduct.

The preputium is a thin-walled sac .162 mm. in length by .09 mm. in diameter at its base, and narrows to the external opening. From its base arises the muscular glans, with a total length of 0.126 mm. The basal half is nearly cylindrical, the distal half conical, its apex terminated by the tubular chitinous armature directed obliquely forward by the curved tip of the glans. The free portion of the tube beyond the epithelium is .027 mm. long. The tube extends beneath the epithelium, dilating into a short cone about .012 mm. long by .019 mm. in diameter. It is evidently developed as a basally secreted formation by the epithelium of the glans.

Close behind the external opening of the penis is that of the vestibulum, the female opening. The lower posterior portion is continued back as the duct of the nidamental gland. The upper anterior part of this duct is imperfectly separated as the vagina, and into it apparently opens the duct of the ellipsoidal sac. The epithelial walls of the blind sac are made up of cuboidal epithelium rather than the flattened type usually found lining the spermatheca. I provisionally identify this organ as the spermatheca, finding nothing else resembling the latter in my dissections of this minute animal. Without sections, it is impossible to be certain of the structure of epithelial cells. In a transparent mount the lumen seemed to contain no spermatozoa although the ampulla was filled. The stages of the cells of the ovotestis indicated that the animal was mature.

#### *Cratena abronia* MacFarland, new species

Plate 59, figures 3, 4; plate 68, figures 18-22; plate 70, figures 1-5

*Body* slender, graceful, somewhat compressed, the dorsum arched from side to side, the sides set off clearly from the thin margins of the foot below, the body tapering behind to the tip of the short tail; head sloping to the rounded anterior margin.

*Foot* narrow, linear, tapering behind, its anterior margin rounded, somewhat dilated.

*Anterior tentacles* cylindrical, tapering toward blunt extremities, divergent, directed forward and upward, two-thirds the length of the rhinophores.

*Rhinophores* smooth, tapering to blunt tips, the bases near together, carried erect, scarcely diverging.

*Cerata* nearly erect, cylindrical, elongated, tapering in outer fourth to blunt tips, arranged in about nine transverse rows on the dorso-lateral margin of the body.

The first three rows quite close, forming the anterior group. This group has from one to five in succeeding rows; the fourth and remaining post-cardiac ones are well separated. The largest number found in the fourth row, five to six may occur, decreasing posteriorly to one or two. These are carried spread in fan-shaped form, after the manner of *Eubranchus*.

*Eyes* clearly seen behind and outside of rhinophores. Statocyst almost spherical in sections .0178 by .015 mm.

*Mouth* T-shaped with inflated lips.

*Anus* on a prominent papilla immediately behind the heart, just within the innermost ceras of the first right post-cardiac group. *Renal pore* just anterior. The syrinx is found on the same row in serial sections.

External *reproductive openings* conspicuous on the right side below the outermost ceras of the second row.

*Mandibles.* (Pl. 68, figs. 18, 19.) Generally ovate, posterior margin a thin rounded point, the anterior portion thickened with a triangular wing curved outward, bearing the masticatory process. This shows a single series of well developed, bluntly pointed denticles, strongest near the posterior end, dying away in the hinge region. There are 18 to 28 well formed denticles; the highest in section measured 0.0055 mm.; it was 0.004 mm. wide at the base.

*Radula.* This was teased apart into three pieces: sheath to tip, 13; sheath to angle, 14; anterior end to angle, 6; total 33 teeth.

Figures show the fifth and sixth angle teeth in side view, eighth and ninth in ventral view, dorsal view shows six to nine denticles lateral to cusp; between are lesser ones. Central cusp does not terminate in knob-like extension.

The lateral prolongations of the base bear a thin triangular edge on the inner curve, widest at the anterior end which articulates with the succeeding tooth. This species varies in this from the other cratenas described with a knob-like tip.

*Color.* (Pl. 59, figs. 3, 4.) The integument of these small aeolids, unmodified by the internal organs and surface markings, is always a translucent gray. The general impression of color is the result of modification by these factors. This aeolid being described, is of a general cream color; the ovotestis, mandibles, and axial liver branches of the cerata are the chief sources of color.

A conspicuous band of purple, a constant mark, inclined to blue, is found about midway of the rhinophores and anterior tentacles, apparently under the surface; below this a narrow band encrustation of pale lemon yellow, the distal third encrusted with the same. In the basal part an occasional specimen showed a diffused coloring of purple.

The mass of color comes from the cerata which contain the terminal liver branches usually colored, the cortex or sheath being clear gray. Three areas of color are here found: the terminal third with a cone-shaped pale cadmium-yellow cnidosac; the central area varying from an olive green to brown; the basal third, a modified carmine.

These areas are set off by bands of surface encrustation of pale lemon yellow, forming the boundaries of the color segments. There are three such bands, a narrow subterminal one, a wide one at the base of the cnidosac area above the central color mass, and the third narrow one at the distal end of the carmine.

This encrustation is found in definite spots: behind the base of anterior tentacles, a pair of spots; in front of the rhinophore bases, a pair; between them and just posterior are yellow flecks; on the dorsum of the heart region; and a definite median line on the tail.

*Dimensions.* Living specimens average in length 5.5 mm. to 13 mm. Specimen painted, 13 mm. long over all; 11 mm. body length; 1 mm. wide; rhinophores 2 mm. long; anterior tentacle 1.2 mm. long; cerata 1 mm. long, 3 mm. wide.

Alcoholic specimens range from 6.7 mm. long, 1.0 mm. wide, 1.4 mm. high to 5.0 mm. long, 1.2 mm. wide, 1.5 mm. high.

*Habitat.* Point Pinos, Monterey Bay; Large Tide Pool; small pools to the right. Found on small algae or floating on surface at low tide. Collected 1899 to 1941. Two specimens by Dr. and Mrs. John W. Robertson, 1941. Rare.

#### EXTENDED ANATOMICAL DESCRIPTION.

*Alimentary system.* Salivary glands studied in serial sections. The anterior salivary gland ducts show, in cross section, the opening into the mouth tube in front of the mandible margin, extending back beside the mandibles laterally, bearing numerous secreting alveoli, apparently unicellular.

The relationships of the posterior salivary glands are uncertain. A duct appears to open on either side of the oesophagus above the radula. A glandular structure, of quite different appearance, is lateral to and above the posterior end of the mandibles. The duct is large and open, the acini have clear cells, those of the anterior gland are denser and darker. The posterior gland extends back but a short distance, while the anterior one continues beyond the limits of the adnexed genital mass. Its alveoli have single, often gigantic, cells .07 mm. in diameter.

The intestine arises from the conical pyloric portion of the stomach, passes immediately to the right and downward behind the posterior border of the adnexed genital mass, loops sharply upward, and terminates in the anal papilla.



The tubular branches from the saccular stomach, situated laterally along with a large posterior one, supply the anterior group and posterior rows of cerata, as in other species described.

*Reproductive system.* The small hermaphroditic ampulla is concealed within a convolution of the mucous gland so that but a small area of its dorsal surface is exposed and is only revealed entirely by carefully dissecting away the glandular mass surrounding it. The ampulla is approximately 0.5 mm. in length and attains a maximum diameter of 0.15 mm. Its distal end narrows rapidly to a short duct which forks into the vas deferens and the oviduct. The vas deferens dilates at once into its thick-walled convoluted prostatic portion, about 0.12 mm. in diameter; distally it narrows abruptly and passes into the base of the penis. (Pl. 70, fig. 1). These prostatic cells are .027 mm. high, very granular, and have nuclei at the base which shows striations. (Pl. 70, fig. 4.)

At the base of the glans the vas deferens is joined by the duct of the adnexed glandular sac. This organ is elongate oval in outline, measures 0.45 mm. in length by 0.255 mm. in greatest diameter. It is closely attached to the base of the preputium, of which it appears to be a part at first sight. Its wall, 0.0825 mm. in thickness, is made up mainly of tall columnar epithelium surrounded by a thin layer of muscle and connective tissue. The cells are cuboidal in shape, finely granular in the distal part, the basal portion with large nuclei. (Pl. 70, fig. 5.)

Preputium (pl. 70, fig. 1) short, conical, containing the short glans. The length of the glans is 0.021 mm. from the base to the apex from which projects the armature. Its basal width is 0.0135 mm.

The armature is a flattened, conical, transparent tube curving sharply downward. Its ventral length is 0.078 mm., slightly more than one-half of which (0.048 mm.) is inserted below the epithelium of the glans, the remainder projecting freely. The basal diameter of the proximal end is 0.054 mm., the diameter at the tip 0.006 mm. The tip is obliquely truncate, the inner curvature coming to a point.

As seen when cleared and mounted in euparal, the proximal part of the cone has a double wall. The outer lies below the epithelium of the penis tip, the inner follows the epithelium of the tip of the duct, seemingly beneath it, but possibly above. Plate 70, figure 3, shows cross sections at the base. Additional sections are necessary to determine this point. The two walls unite before the tip of the glans is reached and continue as a single curved tube. Within this tube a few flattened nuclei may be made out, as though the duct epithelium might be prolonged within it for a distance. On the concave side of the tube the outer glans epithelium appears as if reflected into two layers as far as the tube extends back, but the innermost of these seems to be continuous basally; if the invagination is from the tip, the outer layer would be the one involved.

Between the outer and inner layers of the proximal funnel-like expansion of the glans armature, a number of radial chitinous fibers span the interval uniting the two plates. In the spaces between them, extend longitudinal muscle fibers. The outer surface of the funnel is faintly ridged lengthwise.

The short oviduct doubles back sharply and opens at once into the lumen of the nidamental gland complex.

Into the genital vestibulum opens the dilated end of the duct of the spermatheca, or receptaculum, a blind pear-shaped sac about 0.225 mm. in length, diameter .180 mm., its duct diameter .0048 mm., lying obliquely upon the antero-dorsal face of the anterior genital complex. Below and slightly behind its distal opening is that of the duct from the nidamental gland.

The relation of the duct of the spermatheca to the gland lumen was undetermined.

### ***Cratena spadix* MacFarLAND, new species**

Plate 60, figure 4; plate 68, figures 12-17; plate 69, figures 6-7a

*Body* rounded, highly arched, set off from the foot by a shallow groove. Sides of head dilated into a thin circular margin, continuous with the anterior. Frontal veil of head expansive, rather prominent.

*Foot* linear, rounded in front, anterior margin thickened, abruptly pointed behind, wider than the body, its margin thin and extended.

*Anterior tentacles* blunt, tapering, spreading horizontally at right angles to the sides, equal in length to the rhinophores.

*Rhinophores* simple, smooth, slightly tapering to a blunt tip; divergent, nearly erect.

*Cerata* arranged in nine transverse rows, cylindrical, rounded at the tip to a point. They are long and tapering, folded back over the body, recumbent and overlapping, held erect only when stimulated. Four pre-cardiac rows, the first on the right side close to the base of the rhinophores with three cerata, second row with four, third, with five; the five post-cardiac rows have five, four, two, one and one cerata in succession. The variation on the left side is slight, the post-cardiac rows are not exactly opposite. The cerata tips cover the short tail.

*Eyes* at the base of the rhinophores, distinct, black.

The *anal opening* on a dorsal lateral line immediately behind the heart elevation. Renal pore just anterior.

*Reproductive openings* on the right side below the first and second rows of cerata.

In the specimen used for mandibles and radula, the bulb was 0.5 mm. long by 0.3 mm. high.

*Mandibles* (pl. 68, figs. 12, 13) thin and delicate, pale amber. Masticatory margin bears a series of what appear to be transverse rod-like thickenings which project beyond the margin as closely set blunt rodlets or ridges laterally in contact with each other.

The shortest of these are at the upper end of the series, nearest the hinge. These measure approximately .008 mm. in length by 0.0027 mm. in diameter. The dimensions increase to about 0.013 mm., the slight curvature of the rodlets and the overlapping making exact measurement difficult. The diameter remains the same throughout.

These are actually teeth projecting freely from the margin of the process, their thickened bases overlapping the front edge of the margin, the overlap being slight at first, increasing to fully one-half the length of the rodlet at the lower posterior end of the process.

The rodlets are nearly straight near the hinge but become slightly curved as the tip is approached. At this tip, with high magnification, the surface seems to show minute spines.

*Radula.* (Pl. 68, figs. 14-17.) Seen in the stained cleared bulb, the older end of the radula reaches the ventral posterior end of the bulb, curves upward nearly to the dorsal portion, and is sharply recurved upon itself, the oldest portion closely parallel to the younger portion.

Within the matrix of the youngest portion, eight teeth are distinguishable. The radula of this specimen has a total length of 2.181 mm. and 127 rows of teeth. From the oldest tip to the angle, 100 teeth; from the angle to the tip of sheath, 27 teeth. The extreme end of the radula overlies the bases of the younger teeth, the loop is closely inclosed in a sac-like epithelial tube. The measurements can be only approximate because of the curvature. Young teeth have a length of .0275 mm.; height .0225 mm.

The oldest portion is coiled back upon itself and tapers down to a thread-like tip with three rod-like segments; the oldest near the end measuring not more than .005 mm. long. From the break to the younger portion are 57 teeth, the last few being cuboidal bases alone. These terminal segments measure .038 mm., .022 mm., and .015 mm. each in length.

In all teeth, the median cusp is well above the level of the first lateral denticle and is worn and blunted. Lateral to it, on either side, are two or three denticles; if two, they are strong and project well beyond the median cusp. The second or third lateral is just above the articular socket and projects above it laterally as a part of its roof. One to four minute secondary denticles, on some teeth; seen from above, between the median cusp and first denticles, these appear on the curve of the tooth. The posterior and sides of the median cusp are definitely rounded down, the posterior projecting beyond the basal curve of the tooth. This is usually in the older portion, and is variable.

On the posterior external face of the base of each tooth is a well marked pocket-like depression into which articulates a rounded process borne on the inner anterior face of the base of the preceding tooth.

There are some features of the radula in the oldest portion that are similar to those of the *Sacoglossa*.

*Color.* The general body color is a translucent gray. Tips of rhinophores and anterior tentacles white, basal portions body gray. A golden-red orange extends almost to the bases of the anterior tentacles on the dorsal surface; the same color encircles

the rhinophores from white tips to within one-third of the base.

The terminal liver branches of the cerata axis are brown in color, varying from burnt sienna to deep burnt umber; they are narrow at the base, terminating below the white tips. This color follows the liver cells into the ducts from the stomach, giving the animal a predominating brown color.

A broad frosted-white band extends from base to tip of each ceras, covering the distal one-third, narrowing at the base, the brown axial color showing along the sides. In pale-colored specimens the white is reduced in amount. Sprinklings of white occur on top of the head, extending in a line along the dorsal side of the anterior tentacles, and backward along each side under the rhinophores.

*Dimensions.* An average living specimen measured 11 mm. long; foot 10 mm. long, by 2 mm. wide; rhinophores 4 mm. long; cerata 3 mm.; anterior tentacle 2.5 mm. long.

Alcoholic specimen, *the type*, measures: length 5.8 mm.; body widest behind the rhinophores, 1.8 mm.; height 1.9 mm. (approximate); length of foot 5.4 mm.; width 1.1 mm.; anterior tentacle length 1.0 mm.; rhinophore length 1.3 mm.

*Habitat.* Taken over a period of years at Point Pinos, Cabrillo Point off Monterey Bay. Not common. Small aeolids occasionally found at low tide floating on the surface of quiet pools.

EXTENDED ANATOMICAL DESCRIPTION. (From the study of serial sections.)

*Alimentary canal.* A thick cuticular layer covers the inner face of the muscle masses on either side of the radula tip, and thick median cuticle covers the ventral side of the mandible hinge ligament.

Immediately on emerging from the nerve ring, the short oesophagus opens into the roomy stomach. The high columnar epithelium shortens to a low cuboidal form but still retains its cilia. The stomach dilates into a large sac behind the pharyngeal bulb and above the adnexed genital mass. At the beginning of the fourth row, at the end of the third of cerata, it gives off dorso-laterally the paired anterior hepatic ducts. The left one passes forward entirely; the right one sends a prolongation backward which ramifies to the fourth group of cerata; on the left the stomach gives off a branch directly to the fourth group.

On the posterior right lateral the typhlosole appears as a ridge of high clear epithelial cells nearly circular in cross section, projecting into the stomach. This fold arises from its outer wall and nearly fills the lumen of the intestine. It is made up of high, wedge-shaped, clear, ciliated cells with distal spherical nuclei. Wedged between these cells are elliptical nuclei of more slender spindle-shaped cells, at a lower level. The cells of the intestine wall are higher than those of the stomach and bear longer cilia.

Behind the origin of the intestine, the stomach passes gradually into the median posterior biliary duct without any obvious external change so that no exact boundary can be fixed. The tube remains very large, extending back to the end of the tail. Opposite groups of cerata diverticula arise, and from branches enter each ceras of the

groups and, expanding, nearly fill them, leaving a narrow space for a delicate framework of connective tissue supporting the blood vessels.

Histologically the change from stomach to biliary passage is signalized by the replacement of the low, clear, ciliated epithelium by a low cuboidal epithelium, the cells of which are crowded with rather coarse granules.

Farther along the median duct and especially in its branches leading to and in the cerata, the cells become higher in groups, bulging out into the lumen at intervals; they are closely packed with large oxyphile granules, the small nuclei often becoming irregular in form and quite inconspicuous.

The distal end of each ceras is occupied by the cnidosac, a thin-walled sac communicating by a narrow opening with the end of the liver branch and outward at its tip. The sac appears to contain a small number of very large cells. (?) compartments, containing red-stained spherules resembling those of liver cells but larger. They appear to have been partially forced back through the proximal opening of the sac into the lumen of the liver branch into which they project. They are spherical cnidocysts.

*Reproductive system.* (Pl. 69, figs. 6, 7, 7a.) The anterior genital complex is elliptical, somewhat compressed. The main glandular mass is 1.7 mm. long, by 1.3 mm. wide, by 9.9 mm. greatest thickness. Its inferior surface convex, its inferior and superior surfaces formed by the windings of the mucous and albumen glands; at the anterior margin is the preputium, nearly transverse in position. From its dorsal proximal end emerges the slender vas deferens, passing backward, dilating into the prostatic portion which is short.

Into the proximal end of the preputium on the ventral side, passes the duct of the adnexed gland, the body of which lies horizontally on the upper face of the adnexed genital mass, its distal end in contact with the anterior of the hermaphroditic ampulla.

The glans is conical, slightly curved, regularly tapering to a blunted tip, sharply bent. Its basal diameter, 0.18 mm.; total length, 0.5 mm. The vas deferens receives the duct of the accessory gland at the base of the glans and runs in a spiral undulating course to the external opening. The surface of the glans and the lining of the preputial sheath are covered by cuboidal cells with very long cilia.

At the tip of the glans, beneath the outer epithelium, is borne a thin-walled chitinous armature which does not project beyond the surface of the tip as in the allied forms. It is 0.016 mm. in length, its proximal diameter 0.0137 mm., narrowing to .005 mm. at the tip in a dissected specimen.

The length of preputium as a whole, measured in serial sections: 0.165 mm.; diameter vas deferens, distal portion .045 mm., of prostate .09 mm. in length.

## Family FIONIDAE

Genus **Fiona** ALDER and HANCOCK

*Fiona* FORBES and HANLEY, *ex.* Alder and Hancock MS, 1851. British Moll., vol. 3, p. x (title page dated 1853, published in 1851). Type (by monotypy), *Oithona nobilis* Alder and Hancock,



1831 (= *Eolidia pinnata* Eschscholtz, 1831). ALDER and HANCOCK, 1855. Monogr. Brit. Nudi-br. Moll., pt. 7, pp. 52-53 (fam. 3, pl. 38a, app. p. XXIII).

### *Fiona pinnata* (ESCHSCHOLTZ)

Plate 68, figures 23-28; plate 70, figures 11, 11a, 12, 12-1', 12-2'

*Eolidia pinnata* ESCHSCHOLTZ. 1831. Zoologische Atlas, Heft 4, p. 14, pl. 19, fig. 1.

*Fiona marina* Förskal, variety *pacifica* Bergh, 1879, does not appear to differ appreciably from *Fiona marina* and should be united with it. Furthermore Förskal's specific name *marina* for *Limax marinus* was preoccupied by Gunnerus, 1770, and hence cannot be used. The next available specific name is that given by Eschscholtz.

The species is widely distributed, having been taken near the Atlantic and Pacific coasts of North America, the Mediterranean, Indian Ocean, the regions of Australia and New Zealand, and the China Sea.

In most instances, it has been found upon driftwood and sargassum, subsisting upon hydroids. *Verella*, and *Janthina*. Distribution may also be aided by transportation on hulls of ships.

*Body* aeolidiform, elongate, somewhat arched above. Sub-pallial margins prominent, continuous behind across following the hindermost groups of cerata. Sides compressed about the foot.

Margins of *foot* broad, thin, extending well beyond the body sides. Anterior angles rounded, tail with a median rounded ridge, broad, tapering, when extended almost as long as remainder of body.

*Head* rounded, bearing upon it a pair of divergent, smooth, tapering tentacles carried horizontally.

*Rhinophores* similar to tentacles, smooth, tapering, divergent, erect.

*Cerata* borne on a thin marginal expansion of the dorsum, are very closely set, cylindrical, tapering to a pointed end; four to six cerata in each oblique row extending well forward. The inner margin of all cerata except the small outermost ones, has a thin sail-like expansion from the base upward through at least three-fourths the length of the ceras. The outer margin of this inner expansion contains a blood vessel which communicates with the surface, forming a series of net-like ridges upon the skin which stand up clearly from the general dorsal surface. They form a system of veins, *afferent*, *a.* returning blood from the papillae to the *heart*. (Pl. 70, fig. 12-1'.)

Along the outer side of each papilla, close to the stalk, is a broad blood vessel passing from its base to the tip. This is the *efferent*, *e.* vessel which carries blood from the heart and connects with the afferent one on the inner membranous margin by numerous cross channels. (Pl. 70, fig. 12-2'.)

This system of circulation is well described by Hancock. He terms the network efferent vessels, evidently a misnomer, since they carry blood to the heart, instead of

away from it. He also points out the probable respiratory function of the general integument.

Pelseneer (1894) denies the presence of two symmetrical veins, afferent and efferent in each papilla, claiming the existence of a venous sinus around the hepatic caecum uniting with an afferent vessel on the inner border.

The *optic ganglion* immediately dorsal to the eye. *Otocyst* present with one large *otolith*. 0.033 mm. in diameter.

*Anal opening* slightly in front of middle of body (exclusive of tail) on a low papilla edged with white.

*Reproductive openings* separate, well forward, just back of the right tentacle.

*Mandibles*. (Pl. 68, figs. 23-26.) The pharyngeal bulb is elongate, conforming closely to the shape of the mandibles. Cutting edge dark brown, wing pale amber. Total length 2.8 mm., maximum width 1.3 mm., height 1.3 mm.

One row of denticles on the masticatory margin, which are crescent-like parallel projections overlapping the margin on the outer surface above which the free end projects; the surface minutely roughened. The process is thick and strong, thinning posteriorly.

*Radula*. (Pl. 68, figs. 27, 28.) One row of teeth, each with a broad, simple, curved base, the cusp with a median, strong, large denticle, and six to seven lateral less prominent ones.

Length of ventral segment .75 mm., dorsal segment 1.8 mm., total length 2.6 mm. From oldest end to angle, 15 teeth; from angle on, 22 teeth, incomplete in sheath 3, making a total of 40 teeth.

General *body color*, on thin edges, translucent gray, becoming a pale cream; pale raw umber in the thickened parts with a pink cast between and anterior to the rhinophores. Liver branches in cerata brown, raw umber, modified by a trace of green. Ovary yellow with dots of white.

*Dimensions*, living specimen. Body to end of cerata 17.7 mm., foot length 14.4 mm., tail fully extended, 14 mm.; over-all length 31.7 mm.

Alcoholic specimen. One used for reproduction-system dissection: body length 16 mm., tail 3.5 mm., total length 19.5 mm.

*Habitat*. Taken by H. F. West from drifting kelp. stipe covered with *Lepas hilli*; a large number, 40 to 50. Third Beach, Monterey Bay, California.

#### EXTENDED ANATOMICAL DESCRIPTION. (Notes from the study of serial sections.)

*Alimentary system*. The stomach appears as a thick-walled muscular sac overlapping the pharyngeal bulb, extending above the cerebral ganglia. From its mid-anterior, ventral surface the very short oesophagus passes downward almost vertically into the pharyngeal bulb.

Behind the central nervous system level, the dorsal epithelium of the stomach shows a number of low folds toward the right; here the right opening into the lateral liver duct appears. The epithelium changes from low cuboidal to large columnar cells packed with granules. This branch extends forward to the most anterior cerata on the right, giving off a branch backward. The left branch communicates widely with the end of the stomach, the epithelium extending into the stomach wall. The lobe dilates, narrowing in the cardiac region, shifting to a more median position to supply the left cerata and sends four connecting channels to the right trunk; the first of these channels is at the posterior end of the heart.

The intestine curves to the right beneath the heart, describes a loop external to the adnexed genital mass opening on the dorsal lateral surface within the cerata group opposite the posterior cardiac elevation. Between this and the heart is the renal pore.

A large salivary gland lies upon either side of the posterior half of the pharyngeal bulb. Each gives off a duct, lined with flattened ciliated epithelium, opposite the position of the otocyst; these pass upward around the cerebro-pleural ganglion, downward lateral to the oesophagus, penetrating the dorsal musculature of the bulb lateral to the radula, close to the exit of the oesophagus. The gland is of the branching tubular type.

*Reproductive system.* (Pl. 70, figs. 11, 11a.) Specimen used for dissection: total length 19.5 mm., body 16 mm., tail 3.5 mm. The adnexed genital mass, length 4 mm.; ovotestis which seems to fill the body cavity is 5 mm. from posterior border to its tip. Beyond it to the end of the tail is 6.5 mm.

The hermaphroditic duct passes into the ampulla, a large convoluted portion lying on the posterior of the adnexed genital mass. From the distal end is given off the vas deferens and the long oviduct. At once the long prostatic segment arises, becoming very narrow and muscular as the preputium is reached, the diameter being 0.05 mm., while the prostatic segment is 0.255 mm.

The preputium is the long slender sheath of the glans penis and opens on a prominent elevation; immediately behind and slightly above appears the female opening.

The penis is visible on the dorsal surface of the mass extending obliquely forward in a sinuous form across the complex to its anterior border, and thence forward to the external opening. At its proximal end, it receives the narrow convoluted vas deferens. Midway of its length, it is crossed by the anterior loop of the prostatic portion of its duct. It is cylindrical throughout and the whip-like glans is seen through its walls. Being longer than the preputium, in its retracted state, the distal tapering end is looped back and forth upon itself within the sheath (pl. 70, figs. 11, 11a).

The extruded penis in several specimens is long, slender, whip-like. Its length appears fully half of the total length of the body.

The female channel is wide, thin-walled, lined with low ciliated epithelium. From its lateral wall develops a plicated, thick, longitudinal ridge projecting into the lumen. The oviduct branch is long and passes backward beneath the female channel, describing two simple loops, returning upon itself to open into the female channel with a total

length of 3.2 mm. In this course it shifts dorsally into the stroma of the ventral ridge of the wall, becoming suspended by it as in a mesentery fold within the lumen of the channel. Its distal opening is at the crest of the fold, 1.2 mm. behind the origin of the duct from the hermaphroditic duct (pl. 70, fig. 11, *ov.*).

The spermatheca is an ellipsoidal sac 0.8 mm. in diameter, 1.3 mm. long, with a very slender duct.

The mucous gland is a large roomy cavity with two folds in its wall, one larger than the other.

## Family AEOLIDIIDAE

### Subfamily FAVORINAE

#### Genus *Hermisenda* BERGH

*Hermisenda* BERGH, 1879. Beiträge zur Kenntniss der Acolidiaden. Verh. d. k.k. Zool.-Bot. Ges. in Wien. Bd. 28 (1878), pp. 573-574.

*Body* slender, elongate.

*Rhinophores* perfoliate, tentacles elongate.

*Dorsal papillae* arranged in oblique and transverse rows, separated into several groups.

Anterior angles of *foot* elongate.

Masticatory margin of *mandibles* armed with a single series of denticles.

*Radula* uniserial, the median tooth with elongate lateral denticles, its cusp serrulate below.

*Penis* unarmed.

The genus *Hermisenda* was established by Bergh to receive *Acolis* (*Flabellina*?) *opalescens* Cooper, 1862, which was described anatomically by him from a study of two specimens, collected by Dall at Sitka, Alaska. The presumably new species of Cooper proved to be identical with *Cavolina crassicornis* Eschscholtz, 1831, which belongs neither to *Cavolina* nor to any previously described aeolid, and, in consequence is the type of the genus *Hermisenda* Bergh.

#### *Hermisenda crassicornis* (ESCHSCHOLTZ)

Plate 55, figure 1; plate 70, figures 13, 14; plate 71, figures 1-14

*Cavolina crassicornis* ESCHSCHOLTZ, 1831. Zoologischer Atlas, Heft 4, p. 15, fig. 2.

*Acolis* (*Flabellina*?) *opalescens* COOPER, 1862. New Species of Californian Mollusca. Proc. Calif. Acad. Nat. Sci., vol. 2, p. 205.

*Flabellina opalescens* COOPER, 1863. On New or Rare Mollusca Inhabiting the Coast of California. No. 3. Proc. Calif. Acad. Nat. Sci., vol. 3, p. 60.

*Hermisenda opalescens* (Cooper), BERGH. 1879. On the Nudibranchiate Gasteropod Mollusca of the North Pacific Ocean, with Special Reference to those of Alaska. I. Proc. Acad. Nat. Sci. Philadelphia, vol. 31, pp. 81-85, pl. 1, figs. 9-12; pl. 2, figs. 1-6. GUERNSEY. 1912. First Annual Report Laguna Marine Laboratory, p. 78, fig. 39 J.

*Hermisenda crassicornis* (Eschscholtz), O'DONOGHUE. 1922. Proc. Mal. Soc. London, vol. 15, pts. 2 and 3, pp. 133-135.

*Body* elongate, slender, not compressed or depressed, broadest in front, tapering behind to the tip of the long slender tail. Above, the body is rounded, its sides below expanding into the broad thin margin of the foot. Margins of the foot nearly parallel for anterior one-fourth of the length, thence gradually approaching each other to the tip of the tail.

Anterior angles of the *foot* are produced into tentacle-like pointed processes, 3 mm. in length, the tips of which are in active motion as tactile organs while the animal is crawling. Anterior margin of foot thickened, bilabiate, with a broad conspicuous groove along its front margin, separating the lips and extending out on the antero-ventral face of the pointed tentacles.

*Anterior tentacles* long and tapering, arising from stout bases at the sides of the head. They are usually directed outward and forward while crawling, but may be thrown upward or recurved as they are kept in active motion.

*Rhinophores* nearly erect, slightly divergent, two-thirds the length of the anterior tentacles, tapering, perfoliate or ringed in the distal half, with from 8 to 10 leaves or rings. No longitudinal ridge in front. Rings are very irregular in size, thickness, direction and mutual relations; some come together as if branching, some are so oblique as to resemble the thread of a screw spiral. In rear view, the median longitudinal ridge is usually absent or only an occasional trace is present.

*Cerata* arranged in five or six groups, the first two clearly separated by the cardiac interval, the succeeding post-cardiac groups less so.

The individual cerata of each group are arranged in closely set slightly oblique rows on the dorso-lateral surfaces of the body, the median space free from cerata, being widest in front and narrowing posteriorly.

The longest cerata are nearest the median line, the outer ones decreasing to quite short, almost rudimentary ones nearest the foot margin.

Each ceras is lanceolate in outline, slightly flattened in antero-posterior direction, and gently curved upward to its pointed tip.

In the first group of the right side, in a large specimen, the cerata are arranged in a triangular-shaped figure, an inverted-V, the arc above and inclosing the reproductive openings.

The posterior limb of the group is made up of three closely crowded rows containing in all 25 cerata; the anterior limb forms a closely set triangular group of about 47 cerata, distinct separate rows not being clearly seen. On the left side the anterior limb has three rows, five to eight in each row.



Between the first and second groups is the strongly marked cardiac elevation.

The second group contains ten oblique rows; the third, fourth, and fifth, four rows each; and the sixth, two rows.

The cerata are readily detached from the body when the animal is irritated and retain their active movement for a considerable time.

The *eyes* show as small black spots behind and close to the bases of the rhinophores.

An *otocyst* with a great number of small otoconia are found in sagittal serial sections.

The *mouth* is a longitudinal slit bounded by rather thick fleshy lips on either side. The anterior edge of the foot is bilabiate, the upper lip notched in the median line.

The *reproductive openings* lie immediately below the middle of the first cerata group on the right side, with a sharp triangular posterior opening.

The *anus* is borne on a conspicuous conical papilla on the dorso-lateral margin of the back between the second and third groups of cerata on the right side above the line of insertion of the uppermost cerata.

The *renal pore* is a minute opening about midway between the first and second groups of cerata on the right side, slightly above the line connecting their lower borders and well in advance of the anal opening.

*Pharyngeal bulb* is 7.9 mm. long by 4.5 mm. wide, 4.2 mm. high. Dark-amber mandibles, strong circumoral ring of muscle; bulb rounded in front, dorsally flattened tapering to a blunt tip.

Ventral retractor muscle is inserted on lower outer face of each mandible instead of on the edge alone; a thick muscle. The anterior dorsal ones are rather thin, inserted on the dorsal surface.

*Mandibles* (pl. 71, fig. 1). Light yellow, strongly convex on outer surface, nearly oval in outline, the lower margin straighter than the upper; hinge region somewhat thickened, the anterior margin above it reflected, moderate in width.

Masticatory process prominent, well developed, its margin bearing some 50 strong, pointed teeth, those nearest the hinge worn away and the smallest simply triangular or rudimentary denticles, the others progressively larger toward the tip of the process, becoming wider transversely of the process and bearing from three to five or more serrula on their outer margins. The outer face of each denticle is continued across the outer face of the mandibular process as a low flattened ridge with shallow grooves between, giving the surface a ribbed appearance.

The teeth of the masticatory margin range in height up to 0.066 mm. (their longest denticles reach 0.006 mm.).

Figure 3 shows outer and inner faces of denticular teeth, outer face 0.120 mm. high; inner margin .072 mm. long.

*Radula* (pl. 71, figs. 2-8) uniserial, of 22-26 strong teeth; from a horseshoe-shaped base arises the median cusp, strong and blunt, its inferior margin bearing numerous (6-14) irregular minute serrulations in a single series, fewer and worn on anterior teeth, but becoming more numerous and larger posteriorly. On the teeth at the angle and those following, they are strong. The longest is usually nearest the tip, measuring up to 0.021 mm., the others of irregular heights but in general diminishing down the cusp.

Each tooth bears laterally a row of three to five strong, slightly curved, lanceolate pointed denticles. Above, the series may be continued by a few rudimentary ones or, rarely, individual denticles may show subdivision.

But a small number (four to five) teeth occupy the lower limb of the radula beyond the angle.

Length of base of tooth at angle of radula of a large specimen, the sixth from the anterior end, 0.36 mm.; vertical height of cusp from base 0.27 mm. Length of base of 23rd tooth in same radula 0.39 mm., its vertical height 0.3 mm. Oldest tooth, three-quarters view, length over all, .522 mm.; base length .323 mm.; spine length .282 mm. measured in natural relations in the radula. An older tooth, 22nd, ventral view, .543 mm.; width of tips of base .257 mm.; length of base .348 mm.; first lateral spine .066 mm. long.

*Color.* (Pl. 55, fig. 1.) The most transparent and lovely in coloring of all the aeolids, brilliant and clear. General body color translucent gray (pale ochre is used over parts of the dorsum to reflect the viscera) ornamented with strikingly beautiful blue and orange stripes arranged as follows: from the tips of the anterior tentacles a narrow light-blue line extends backward along their dorsal surfaces, widening as the base is approached and becoming lighter in its median portion, the margins remaining much deeper in color; prussian blue in a pale wash was used. The anterior marginal portion of this dorsal band on either side curves around the front of the rhinophores and passes backward along the median dorsum of the body, the two lines bounding a median elongated spot or stripe, cadmium yellow, its margins with a narrow chrome-orange line, becoming lighter in the central area. This orange band begins well forward between the anterior tentacles and extends backward to a point approximately opposite the middle of the anterior group of cerata. As it narrows behind the lateral bounding, lines of blue approach and coalesce, separating again in the cardiac region to bound a similar but narrower median band of lighter orange or yellow of length nearly equal to the anterior one. Behind this second, median, yellow stripe, which may be quite inconspicuous or even absent in some specimens, the blue lines unite again in a single, narrow, median line which runs more or less continuously to the tip of the tail.

The outer marginal portion of the double, dorsal, blue line along the anterior tentacle continues backward dorso-laterally to the base of the first group of cerata. Between the successive groups this marginal blue line appears connecting them, and behind the last group it is continued faintly toward the tip of the tail.

Immediately below the anterior portion of this dorso-lateral band is an orange

or yellow band on the side of the head, extending from below the bases of the anterior tentacles backward toward the first group of cerata. It is much better developed in large specimens than in smaller ones and may be absent.

Along the antero-dorsal margin of the foot tentacles, a narrow blue line may be present extending from their tips toward the base of each. Behind each foot tentacle a wider marginal blue line extends backward along the dorsal surface of the edge of the foot to the tip of the tail, meeting its fellow and the median dorsal stripe at that point. A narrow white line marks the outer edge of this marginal blue line.

All of these lines are subject to variation in depth of color, being best developed in large vigorous specimens and less so in younger individuals. Dredged specimens tend to show much less conspicuous coloration in general than those taken in shore collecting at low tide.

The *cerata* have an axial branch of the liver ranging in color from light burnt umber to deep brown. The tip is white, below which is a subterminal zone of yellow to deep chrome orange, gradually becoming lighter below, which may reach one-fifth to one-fourth of the whole *ceras* length. Near the tip, a sprinkling of white may occur which is continued as a bluish-white band down the anterior face of each *ceras*. (This line is not present in all specimens.)

Depending upon the maturity of the specimen, the ovotestis shows through the body wall as a more or less conspicuous pink mass.

While the intensity of color appears to vary in different specimens, all observers, from Eschscholtz and Cooper on, seem to have found constant the median stripe of orange or yellow between the rhinophores, the longitudinal lines of light or pale blue to white, and the axial light or dark brown of the *cerata* being more variable in extent and depth of color.

Specimens from inclosed bodies of water have the *cerata* axis pale quaker gray to very dark, while the blue lines are paler than in those of open bays.

O'Donoghue does not seem to have found specimens in the Vancouver region showing the posterior median orange or yellow line in the cardiac area. Such markings are quite common, however, in California specimens.

While the brilliant colors fade and change upon preservation, I cannot confirm O'Donoghue's statement that the markings are thus lost, for in nearly all my preserved material the characteristic lines are still readily recognizable.

*Dimensions* of large living specimen. Total length 79 mm. (tip of head to tip of tail). Length of foot 74 mm.; width of foot at anterior end, just behind anterior angles, 12.7 mm.; width of foot, midway of its length, 16.4 mm.; tip to tip of anterior angles of foot 20 mm.; length of anterior tentacles 13 mm.; spread of tips of anterior tentacles 24.5 mm.; length of rhinophores 10.3 mm.

Alcoholic specimens vary greatly; a medium-sized one had a length over all of 25 mm., with 5 mm. added for curved tail; height 8.7 mm.; width, anterior end of foot, 6.5 mm.

*Habitat.* *Hermisenda crassicornis* has been reported from Sitka, Alaska, Dall,

August 18, 1865. 6 to 10 fathoms. Two specimens were studied by Bergh (1879). Dall's color sketches give general color as grass green, paler on ventral surface of foot, rhinophores whitish. cerata purple-red; yellow vessels on the lateral part of the back along the papillae (hepatic ducts?) shining through the integument. Length seven lines (=14.21 mm.) alive. In alcohol 12.5 to 13.0 mm. long.

First collected by Otto von Kotzebue, 1824, Alaska. Collected by G. Dallas Hanna, 1947, Ketchikan, Alaska. Other collections were as follows: by Cooper from San Diego Bay, Santa Barbara Coast, and Santa Barbara Island; by Myrtle Johnson from San Diego Bay; by Cockerell from San Pedro; by Guernsey from Laguna Beach; by MacFarland from Monterey Bay, Carmel Bay, Point Sur, and Moss Beach; by Agersborg from Puget Sound, near Victoria; and by Taylor from Puget Sound, near Victoria.

*Hermisenda crassicornis* is very common in rocky tide pools and on wharf piles, and has been dredged from a depth of 16 fathoms.

Laid in an aquarium. *Hermisenda* egg bands are pale pink, the outer diameter being 9.5 mm., width of each turn 2 mm., 3 turns in all. The eggs are in a narrow flattened band 0.5 mm. in widest diameter which is closely looped above and below toward the center of the coil.

It is very active in confinement and is quite voracious and irritable, attacking other nudibranchs and members of its own species indiscriminately. Its cerata are very readily cast off when irritated, and all stages of their regeneration are readily found.

#### EXTENDED ANATOMICAL DESCRIPTION.

*Alimentary system.* The duct of the posterior salivary glands passes through the nerve ring at the side of the oesophagus and in front of the buccal commissure, curves downward through the roof of the pharyngeal bulb, and opens into the posterior mouth cavity lateral to the anterior end of the radula sheath. Proximally, the duct ramifies into a branching tubular gland close behind and above the posterior end of the bulb and immediately below the integument at the bases of the anterior cerata group.

The stomach is very large and capacious. Its anterior end bears numerous, closely set, longitudinal folds extending backward from the oesophagus and laterally breaking up into rows of high villi along the left greater curvature of the stomach. The mid-posterior-dorsal wall develops closely set low ridges which converge toward the pylorus and the intestine. The intestine arises just in front of the heart, loops downward, backward, and upward to the anus situated on a conspicuous cylindrical papilla on the dorso-lateral margin between the second and third groups of cerata. Just in front of the intestine is given off a broad hepatic branch to the first group of cerata of the right side; a similar one arises from the anterior left side and in the median posterior line; another broad branch supplies the posterior cerata.

The renal syrinx shows through as a deep, red, pyriform body and opens into the pericardium at the anterior right side opposite the position of the renal pore externally.

*Reproductive system* (pl. 71, figs. 9-13). The nidamental-albumen gland complex is almost hemispherical in form, lying mainly on the right side, its flattened surface

directed inward and upward, the convex surface toward the right body wall. In front it is in contact with the large preputium, its inner surface resting against the stomach.

The delicate, transparent, small hermaphroditic duct arises by the union of ducts from the ovotestis lobes into a common tube along the median line. It passes forward above the large posterior hepatic duct, dilating into the ampulla which is coiled upon the posterior face of the adnexed genital mass, passing downward to the left face, and making a sharp bend upward, it gives off a very delicate tube, the oviduct; the larger vas deferens reaches the preputium into which it opens.

The preputium is a large sausage-shaped sac lying obliquely upon the genital complex, the bulk of which it forms fully, one-half being 5 mm. long by 1.7 mm. maximum diameter. Close in front of the entrance of the vas deferens is inserted a strong retractor muscle; three others, more slender, are inserted close to this.

The cylindrical preputium is thin-walled and its cavity filled with the glans. This is cylindrical in form, its tip bluntly tapering. Its total length is about 3.5 mm. in length, its average diameter 1.0 mm. Midway of its length, it bears a band of four to five rows of conical tuberosities, immediately behind which is borne a large, conical, wing-like elevation. This is covered with papillae continuous with the band adjoining it. Distal to this zone, the surface is thickly set with minute villousities. The papillae and villousities are well seen in specimens which have been killed with an inverted glans. The apex is rounded with a central opening into the deferent canal, and is destitute of an armature. Dimensions, everted penis: length 6.2 mm. long in an individual 24 mm., foot length, 29.0 mm. over all. Ring of papillae distended, apex beyond ring finely punctuate, at times inflated. Tip curved forward, angular wing on dorsal surface prominent, its tip curved backward. Cylindrical portion of penis two-fifths of the entire length.

Notes from serial sections. The penis is everted and folded back parallel with the body wall so it is cut transversally through its whole extent. A thick-walled muscular structure lined by a high one-layered columnar epithelium with small deeply staining basal nuclei. The cells are filled with small rounded secretion granules, albuminous in nature. The large lumen contains masses of these granules. The distal end of the cell bounded by a clear-cut deeply staining line within which is a single row of nuclei. In places, droplets like round masses of secretion granules project through the cell membrane or in contact as if just extruded. The proximal end of the cell above the nuclei shows an alveolar meshwork. The epithelium rests upon a thin layer of connective tissue and a thicker layer of smooth muscular fibers. Outside of this layer is a wide system of blood lacunae followed by interlacing muscular fibers. The external surface seems to be covered by thin, flat, one-layered epithelium.

In the basal or smooth cylindrical portion of the penis, a large space between the lining epithelium and the muscular wall at times almost completely surrounds the former with a few strands of muscle crossing it. It is not clear whether the large space is entirely a normal blood sinus or due in part to shrinkage. The epithelium shows little evidence of this.



A histological study was made of the external surface of the penis from the same serial sections.

The wing-like ridge appears on the anterior face of the penis and is composed mainly of longitudinal fibers with a clearly developed, outer, circular layer and more irregular fibers on the lesser curvature, with oblique bundles between. A definite layer of superficial nuclei appears as if of flattened epithelium with scanty cilia. The rounded conical papillae of the girdling band also appear on the slide. Each papilla is a dense mass of interlacing fibers, mainly muscular, with numerous nuclei surrounded by clear areas between; the surface is covered by flat pavement epithelium with no cuticular modification. No gland structure of any kind is evident at the surface.

These rounded papillae are succeeded by the distal zone of slender papillae, nearly filiform with blunt tips. Each is made up of a single pile of flattened cells or of more than one row as shown by their nuclei. The structure is strikingly like a stratified epithelium. The surface seems covered by very thin epithelium. In tangential sections, at the tip, the papillae seem to be sinuous ridges, narrow, one cell in thickness.

The glandular epithelium lining continues out beyond the conical tubercle zone well toward the apex, doubles back parallel with itself to the distal boundary of this zone, and again turns outward. The cells have decreased in height and the cilia become longer. The gland cells are replaced by low ciliated ones becoming cuboidal and arranged over longitudinal ridges.

Bergh (1879) stated that "a layer of rather short sacculate glands filled the end of the penis around the orifice." (Nudibranch. of North Pacific, p. 85.)

Nothing resembling this has been found by me in any of my sections, and it is difficult to imagine what he may have seen that inspired such an interpretation. Without sections, however, no accurate determination was possible to him.

The female opening is a vertical cleft behind the opening of the preputium. It leads into a roomy triangular vestibule with plicated walls. Externally, it is a short, broad, sac-like organ opening immediately behind the preputium. It lies external to the anterior portion of the adnexed genital mass, into which it opens from its inner face. It is compressed laterally. Its external aspect shows a shallow constriction which divides it nearly equally into anterior and posterior portions.

This organ is widest at the external opening and is directed backward and tapers apparently to a blind end. About midway of the lower outer face, a short wide duct appears which leads into the nidamental gland. Opening into the lumen of the vestibule, it is well forward on the ventral side. It dilates at once into a flattened elliptical portion and again narrows into a short duct parallel and close beside the oviduct. It apparently passes into the nidamental gland near the entrance of the oviduct.

The oviduct passes straight backward parallel to the distal portion of the hermaproditic ampulla and opens into the albumen gland, or probably into the fertilization chamber. It is concealed beneath the straight distal segment of the ampulla and is revealed by raising the latter from the groove in the mucous gland in which it lies. A thin-walled elliptical sac, the spermatheca, seems to arise from the oviduct close to its entrance into the albumen gland.

Genus *Phidiana* GRAY

*Phidiana* GRAY. 1850. Figures of Molluscous Animals, vol. 4, p. 108, = *Cavolina* d'Orbigny.

*Phidiana nigra* MACFARLAND, new species

Plate 62, figures 1-3; plate 70, figures 15-16a; plate 71, figures 15-20

*Body* elongate and compressed, but rather stout, especially about the head extremities. Foot narrow, extending well beyond the sides of the body, set off by a lateral groove, widened foot edge continuing to the tip of the long pointed tail.

*Foot* with its anterior margin thickened and rounded, not at all produced at the angles, bilabiate with a shallow groove, the upper lip much thicker than the lower. No median notch.

*Anterior tentacles* long and tapering, with pointed tips directed outward and forward, bases very stout. The median anterior margin gently curved into a slight central notch.

*Rhinophores* thickened, tips slightly truncate, non-retractile; sheaths perfoliate, with about 14 horizontal leaves. The clavus scarcely thicker than the stalk, edges slightly thickened in front and behind, giving an elliptical cross section, while the stalk is circular. The plates encircle the entire clavus with scarcely a trace of a median axial ridge in front and behind. A few incomplete plates on the posterior half die away to the front. There is a slight triangular thickening prolonged a short distance down the clavus from each lamella on the anterior median line. (Pl. 62, fig. 3.)

The *cerata* are arranged in two groups separated by the heart region. Each group is composed of closely set oblique rows of numerous lanceolate cerata overlapping each other, and in the anterior group being almost parallel with the long axis of the body. The individual cerata increase in length from the sides toward the center and from anterior to posterior.

The first group on the right side forms a long wide arch extending, from in front of and lateral to the rhinophore bases, backward to the heart region, one-half the length of the body. The group is made up of very closely set oblique rows, an average of ten rows, although the number is quite variable. In dissection, the following count was made of ten rows:

<i>Row</i>	<i>Number of cerata</i>	<i>Row</i>	<i>Number of cerata</i>
1	3	6	4
2	5	7	7
3	6	8	7
4	7	9	about 10
5	4	10	about 10

The second group includes the remainder posterior of the heart and in many specimens indistinctly divisible into several subdivisions. The anterior division arises just dorsal to the posterior of the anterior group and arches backward, laterally forming a crescentic curve. A median space of the dorsum is left free of cerata back of the anterior group, but posteriorly the entire dorsum is covered. In this first division are nine oblique rows. The remaining groups, three to four in number, are indicated only by the outermost cerata of the rows. As many as 20 rows may be on the posterior dorsum. They are not readily detached.

*Eyes* show faintly through the integument just back of the rhinophores.

*Otocyst* is present, but otoliths not visible.

A thick glandular mass surrounds the *mouth*. The opening is a long vertical slit. (Pl. 70, fig. 15.)

The *reproductive openings* are on the right side slightly in front of the center of the body below the posterior end of the first group of cerata.

The *renal pore* is slightly in front of the middle of the second group and below it.

The *anal papilla* is 6.4 mm. behind the renal pore.

*Pharyngeal bulb* is large and strong, the length, 6 mm.; height, 4 mm.; width, 4 mm.

*Mandibles* (pl. 71, figs. 15, 16) oval in outline, hinge strong, deeply arched, ventral margin straighter than the dorsal. Cutting edge slightly curved, about one-half the length of the entire mandible. Armed with 25 to 30 irregular blunt denticles which interlock when closed.

*Radula* (pl. 71, figs. 17-20). The teeth are in a single series, increasing somewhat in size from the anterior to the posterior end of the narrow radula. Two radulae were used in the study, each with 21 teeth, two embryonic ones at the end, ten in the sheath, four at the angle, five to the tip. They are light brown, with the exception of the tips of the main cusps and denticles which are slightly different in appearance. Each tooth consists of a strong horseshoe-shaped base from which arises a triangular oblique portion terminating in a median cusp directed more horizontally backward. The sides bear a single series of denticles, four to six large ones on the lower margin, three to four smaller ones continuing to the tip of the cusp.

Measurements of oldest tooth: length of base .315 mm., width of base at tips .28 mm., ventral height of cusp above base .165 mm., total length of tooth (anterior end of base to tip of cusp, horizontal) .465 mm.

*Color* (pl. 62, figs. 1-3). The general body color is a neutral gray; the foot is quite pale with wide, thin, transparent margins. The dorsum is a warm ochre hue, the viscera showing through the integument. The frontal region is a suffused orange-yellow which becomes a rich orange upon the lowermost plates of the rhinophores, fading to a pale yellow above.

The anterior tentacles are a bluish white, which color is prolonged over the anterior region of the head. A line of deep, rich-orange color follows the contour dividing this area and extending onto the dorsal basal fourth of the anterior tentacles. A short line of this color is found in larger specimens midway of their ventral surface.

The axial portions of the cerata are a dark brown, outlining lighter colored nodules of the liver branches. These branches vary from light to deep brown or even black, always deepening at the base. The larger cerata have tips of white, smaller ones of a golden shade, in each case surmounting a subterminal clearer zone beyond the dark liver branches, the periphery always being the clear body color.

Over all, the surface is a beautiful rose pink, madder carmine covering the distal two-thirds, fading out below. This is not so perceptible on the small cerata as the liver branches almost completely fill them, the dark mass making dim the carmine. A patch of superficial white of irregular form and extent lies just below the subterminal zone; the white tips and this patch are constant even in preserved material. (Pl. 62, fig. 2.) The front and outer surface may bear small, irregular incrustations of white.

A pale-blue line follows the dorsal edge of the foot and the median region of the tail, both encrusted over with dots of white.

Colors used in painting are burnt umber, deepened by the use of black, and madder carmine for the cerata axes with the wash of carmine over all.

*Dimensions* of living specimen: body length 42 mm., height 8 mm., foot length 37 mm., width 6 mm., anterior tentacle length 7.5 mm., rhinophore length 5 mm.

A large specimen, crawling, had a body length of 75 mm., width 8 mm., maximum height 10.5 mm., foot width at anterior end 8 mm. narrowing to 6 mm., anterior tentacle length 12 mm. In November, 1932, afternoon tide, ten large specimens were taken at Cabrillo Point. The largest had a body length of 50 mm.; foot, 43 mm.

Preserved specimen: body length 30 mm., height 8 mm., width 6 mm., foot length 24 mm., foot width 4 mm., anterior tentacle length 6 mm., rhinophore with about 14 horizontal leaves. Added details from another specimen: from the anterior margin of the head to posterior end of cerata, 30 mm.; tail beyond cerata 4 mm.; anterior margin of head to end of first group of cerata, 11.8 mm., slightly more than one-third body length.

*Habitat.* Monterey Bay, rocky pools, most frequently found at Cabrillo, Aulon, and Pinos points. Taken as far south as Carmel Bay Point. Living often on hydroids among corallines, occasionally upon kelp. Not as common as *Hermisenda crassicornis* with which it frequently occurs.

#### EXTENDED ANATOMICAL DESCRIPTION.

*Alimentary system.* Notes taken on the salivary glands from the study of serial sections. Entrance of salivary duct, inner opening, at the side of the rotula, well forward and midway of the height of the cavity beneath the rhinophore bases.

The duct of the posterior salivary gland emerges from the bulb, dilates to considerable size before emerging, passes through the nerve ring close below the cerebropleural ganglia. It branches at once into tubular divisions which ramify to the dorso-

lateral body region, especially to the ridge bearing the cerata groups. The branches pass backward beyond the level of the renal pore, lateral to the stomach, to the liver.

From the dorsal side of the bulb a little behind its middle point, the short oesophagus emerges, courses backward for 2.3 mm. and dilates into the roomy stomach. The stomach is pear-shaped, the broad end anterior, of a grayish color, thin-walled, with faint external indications of internal longitudinal folds in its walls. The epithelial lining is composed of tall glandular cells, with small deeply staining nuclei, the remaining portion is full of large acidophile spherical granules of fairly uniform size, the largest of which are fully one-third the diameter of the nuclei. The basal end is filled with finely fibrillated cytoplasm.

Upon its upper posterior face, it bears the large biliary division. This is triangular in shape, its anterior portion being prolonged laterally into a hepatic duct, on either side from which branches pass to the anterior groups of cerata.

Posteriorly, it is prolonged in the median line into a similar diverticulum into which the median posterior hepatic duct opens. This duct receives lateral branches at intervals from the cerata of either side, and extends backward in the median line above the reproductive gland lobes to the tail. The margins of the dorsal hepatic division of the stomach are strongly sacculated in strong contrast to the remainder of the organ.

The posterior dorsal portion of the stomach tapers rapidly into the intestine which loops downward on the right to the floor of the body cavity, thence obliquely backward and to the left, curving upward around the first lobe of the ovotestis, thence obliquely backward to the right and upward to open at the anus by an inconspicuous pore behind the second and third groups of cerata much farther back than usual. The posterior segment of the intestine, the rectum, presents a gradual enlargement from 0.5 mm., at its narrowest portion, to 1.6 mm., thence narrowing rapidly to the external opening.

Renal syrx short and wide, flattened spheroid, its epithelium much folded.

*Reproductive system.* (Pl. 70, figs. 16, 16a.) Tributary branches from the lobes of the hermaphroditic gland arise, forming a median duct which passes forward to the middle of the adnexed genital mass. It bends to the left, dilating into the elongate thin-walled hermaphroditic ampulla. This loops downward on the left side and returns to the middle dorsal line, lying deep within the cleft of the mass.

The anterior portion of the adnexed genital mass is formed by a thick hemispherical glandular mass, the anterior lobe of the mucous gland, which turns ventrally into the smaller thinner lobe, leaving between the two a deep transverse notch occupied by the coils of the ampulla and the smaller albumen gland, the vas deferens and penis on the right.

In the bottom of the depression the ampulla narrows suddenly, gives off the vas deferens as an external branch, and opens as the oviduct into the lumen of the gland complex near the appearance of the external duct of the latter.

The vas deferens thickens at once into a thick-walled glandular tube which passes, after a few close windings, into the penis. The prostate has a strong muscular wall



composed mainly of circular fibers, with a less clearly defined outer longitudinal layer.

The preputium is a cylindrical cone 1.9 mm. in maximum diameter by 3.5 mm. long. The vas deferens, apparently partially invaginated into the proximal end, is .8 mm. in diameter, at entrance decreasing to .2 mm.

Dissecting away the dorsal wall of the preputium, the cylindrical glans is exposed. It is a stout structure 2.5 mm., tapering to a point upon which is borne a minute chitinous black hook curved antero-dorsally. The lumen of the vas deferens is continued to this apex and opens externally at the tip of the hook.

Close behind the external opening of the preputial sac is the opening of the common vagina and accessory gland duct which communicates with the lumen of the nidamental and albumen glands close to the entrance of the oviduct. Onto it opens the short duct of the spherical spermatheca, 1.3 mm. in diameter, visible only on the mid-ventral surface of the adnexed genital mass. (Pl. 70, figs. 16, 16a.)

### Subfamily AEOLIDIINAE

#### Genus *Aeolidia* CUVIER

*Aeolidia* CUVIER, 1797. Tabl. Élém. Hist. Nat., p. 388, Paris. 1798 (December 24, 1797). Type, *Aeolidia papillosa* Linnaeus=*Doris papillosa* (Linnaeus) of Gmelin, 1790, not Müller, 1776, =*Limax papillosus* Linnaeus, 1761, Fauna Suecica, 2d ed., p. 508.

#### *Aeolidia papillosa herculea* BERGH

##### Plate 72, figures 1-8

*Aeolidia herculea* BERGH, 1894. Bull. Mus. Comp. Zool., Harvard Coll., vol. 25, no. 10, p. 128, pl. 1, figs. 8-12.

DESCRIPTION. Specimens from Monterey Bay and Waddell Creek Reef, California.

*Body form* elongate, broad, back smooth, slightly depressed, sub-truncate in front, produced behind into a short, broad, flattened, pointed tail, scarcely extending beyond the cerata.

*Foot.* Anterior margin rounded, produced into rounded angles. Margin bilabiate, deeply two lipped, notched in the median line. Lateral margins of foot prolonged beyond the body in a thin, translucent, undulating line.

*Anterior tentacles* slightly shorter than rhinophores, borne on the rounded outer angles of head margin with widened base and pointed slender tips; carried turned outward.

*Rhinophores* simple, conical, blunt, tapering, generally smooth. A few specimens are recorded with small, oval, obscure elevations on the surface but these seem to be exceptional.

*Cerata* flattened, lanceolate, with the anterior surface convex, the posterior slightly concave; edges thick and rounded, with narrowed ends and pointed tips; widened at

the base; borne very close together and arranged in about 24 transverse rows, the first 8 to 10 in front of and lateral to the rhinophores. They extend forward to immediately behind the tentacle bases; backward the dorsal area gradually narrows, the rows meeting behind the heart. Posterior of the cardiac region the entire dorsum is occupied by cerata. The oblique rows slant upward and backward from the upper margin of the foot along the sides of the body. In crawling, they are carried close in a horizontal position, resting upon each other, or are strongly curved toward the mid-body in the series nearest the mid-line; lateral ones curve outward. While most of them have simple pointed tips, many are bifurcated slightly or deeply; the subdivisions likewise may also be cleft.

The *eyes* are seen just back of the rhinophore bases, practically sessile, deep down at side of the complex.

The *anal papilla* is dorso-lateral on the right side between the cerata, rows 9 and 10 from the front.

*Renal pore* lateral, slightly anterior to anal papilla, according to Odhner, 1939.

*Reproductive openings* on right side at the outer ends of the posterior rows, 8 to 10 of the most anterior group of cerata.

Specimens from Waddell Creek Reef, central California, and from Kodiak Island, Uzinki, Alaska, were dissected for radulae and mandibles. The first was 40 mm. long, the bulb, 6 mm. long by 4.5 mm. high, 3.6 mm. wide.

*Radula* (pl. 72, figs. 5-8) curved in form of hyperbola with 18 teeth, strong basal cuticle extending over the sides of the mass in a cap-like manner, bearing the radula rotula at its crest; at the bottom of the lateral furrow it is redoubled upward. Radula of a simple series of teeth, pectinate, arched, and curved forward, bearing a series of stout, regular, lanceolate tipped denticles, 38 to 43 in number.

*Mandibles* (pl. 72, figs. 1-4) light amber, oval, hinge region thick and strong. Outer face but slightly convex, nearly flat, the posterior thinner end approaching the median plane very slightly. The anterior portion thick and strong, the hinge at the summit of a pyramidal elevation marked externally by a slight depression at the anterior margin of the mandible. Attached along the anterior ventral edge is a strong, curved, masticatory process, free only at the tip. Extending to the margin from the anterior end of the hinge is a distinct cleft terminating in a notch at the anterior margin. Two specimens from Kodiak Island, Alaska, were in a contracted condition; one was 27 mm. long in a straight line, 60 mm. curved; when living it probably reached a length of 100 mm.

*Pharyngeal bulb*, greatest length, 8 mm.; mouth to oesophagus, 6.5 mm.; maximum thickness 4.8 mm. Mandible deep brown, thick and strong, the hinge region prolonged anteriorly in a stout, thickened, triangular process. Full length from this tip 8.9 mm., width 4.6 mm., length along masticatory margin 4.4 mm. The triangular apical process includes the entire hinge region. Radula teeth, 32 plus 5; total, 37, borne in a

simple arch with no sharp angle. Anterior boundary of sheath vaguely defined, some 11 or 12 teeth functional, but this is uncertain. Sides of the radula prolonged downward as continuous strong cuticle over the lateral surface of the rotula. Posterior end of sheath projects, but slightly, from the surface of the pharyngeal bulb.

Teeth are strongly arched, occupying the crest of the ridge-like radula; each bearing uniform comb-like denticles directed backward; on five successive teeth, these averaged 42 each. The teeth are flexible and readily bent. The spread at the base of the larger teeth was 4 mm., of smaller ones 2 mm.

*Color* of California living specimens. The average specimen of median size has a general body color of dull rose, mauve, varied at times to a drab gray. This mauve color continued over the anterior tentacles and cerata. The rhinophores are a darkened shade of the body color and may be darkened by an irregular mottling of minute flecks of brown to gray. These flecks are scattered over the surface of the anterior body and cerata, deepening the general color.

The axial liver branches of the cerata are clearly defined and lobulated, of varying shades of brown amber to olive, wide at the base and dark, becoming narrow and pale in the distal part; a conspicuous cone of white is inside the tip. The margins are transparent and of the body color. On the inner margins of the cerata of the median rows is a narrow encrustation of white extending two-thirds the length. This is absent on the outer rows, giving the area of the sides with the closely set cerata a darkened appearance.

On the head, anterior of the rhinophores, is always found a large crescentic spot of encrusting white or cream, irregular in outline, the arms being prolonged onto the dorsal surface of the anterior tentacles to the tips. Likewise behind the rhinophores, extending to the cardiac region, there is a small irregular spot of white or cream, which has behind it a larger denser one covering the cardiac area and breaking up into smaller dots posteriorly. This may be of a pink shade or even with a metallic sheen. The light-orange area of the anterior dorsum may come from the reproductive lobes.

Large specimens show varying degrees in depth of color, some quite dark. The encrusted spots, which are constant, vary from white to cream to a salmon red. This last color is on the head spot and the margins of the small cerata of the head region.

*Dimensions.* Living specimen from shore collecting, Monterey Bay. Body length 42 mm., width 11 mm., height 7 mm., foot width at anterior end 13 mm., anterior tentacle length 10 mm., its spread 18 mm., rhinophores length 7.5 mm., distance apart 1.5 mm., basal diameter 1.5 mm., length of head from rhinophores to anterior margin 8 mm., anterior head margin between tentacle bases 8 mm.

The largest specimens from Monterey Bay range from 38 to 64 mm. in length. Alcoholic specimen taken at Waddell Creek Reef had a body length of 43 mm., height in cardiac region 10.5 mm., foot width at anterior end 14.7 mm., length of foot 39 mm., rhinophore length 4 mm., anterior tentacle length 5.6 mm., diameter at base 1.7 mm.

*Habitat.* It is a fairly common aeolid along the central California coast and northward, having been taken by me from 1897 to 1947 from the pools of inner Monterey Bay. Taken by W. K. Fisher south at Point Lobos, by H. Heath, H. Wells, G. E. MacGinitie, and R. Bolin, from the inner Bay.

A large collection of this species was made by me in 1925 from a reef extending from Waddell Creek, Santa Cruz County, California. It was found feeding on colonies of shore anemones. These, too, are the feeding ground in Monterey Bay pools.

### Genus *Aeolidiella* BERGH

*Aeolidiella* BERGH. 1867. *Phidiana lynceus* og *Ismaila monstrosa*. Naturh. Foren. Vidensk. Meddel. p. 99, footnote. (Videnskabelige Meddelelser fra den naturhistoriske Forening i Kjobenhavn, 1866.)

### *Aeolidiella oliviae* MACFARLAND, new species

Plate 62, figures 4-6; plate 72, figures 9-14

*Body* broad, flattened; sides and outer margins of the dorsum completely covered by the short pointed cerata, directed backward, closely overlapping; head rounded rather high, anterior margin in a rounded curve; length 25 mm., breadth of body over cerata 6 mm. (1904 specimen).

*Foot* broad, lancet-shaped with thin margins, extending beyond the sides of the body. Tail moderate. Anterior angles much produced into tentacle-like processes which are thickened and marked by a shallow groove, making two lips continuous across the anterior end of the foot, the lower the thinner.

*Anterior tentacles* long, cylindro-conical, the tip rounded, directed forward and outward, twice the length of the rhinophores.

*Rhinophores* are kept in constant motion when crawling, erect, not retractile into sheaths. The clavus much longer than the very short stalk, nearly cylindrical, tapering at top, bases close together. The clavus perfoliate, the laminae almost vertical, running obliquely upward and from behind forward, arising from the base and the median ridge on the posterior face. Often a short incomplete ridge alternates with this one or passes to the median one of the anterior face. On this the leaves unite low down on its sides, leaving the top free.

*Cerata.* In the living specimens they are short, cylindrical, pointed at the tips, directed backward, overlapping, constricted at the base. The most lateral rows are at right angles to the body. They are arranged in 17 oblique rows, the dorsal inner ones being the longest; bases wide apart in the median line in front, becoming closer in the cardiac region, the inner ends of the last rows approach but do not meet; thus the dorsum along its median line remains free of cerata.

*Mandibles* (pl. 72, figs. 9-14). Specimen collected by George E. MacGinitie, Large Tide Pool, Point Pinos. Length 23.3 mm. Bulb (removed) length 1.9 mm., height

1.4 mm., width 1.2 mm. Oval in outline; almost the entire lateral face of the mandible is exposed, a light yellow-brown color. Within the anterior half is an empty cavity bounded laterally by the two mandibles, free from the inner muscles which form its posterior wall. The mouth tube, 0.7 mm. in length, emerges from the antero-ventral wall. The hinge region is far forward, directly above the anterior margin of the mouth tube. The oesophagus appears from the posterior half of the upper surface and arches upward and backward through the nerve ring. The relations of the nerve ring must be taken from another specimen as it was here broken in the removal of the bulb. The external layers in the anterior portion are quite thin and do not show the mandible color appreciably.

The dorsal surface of the bulb is flattened, with the bounding margins of the mandibles widely separated. The posterior face of the bulb is convex, its muscular wall projecting behind and above the hinder end of the mandibles. There is no special prominence caused by the radula matrix and sheath.

Within the anterior chamber of the bulb the radula projects slightly in the mid-posterior wall, flanked by muscles running dorso-ventrally on each side. The regularity and symmetry would indicate that the cavity is not a product of constriction shrinkage entirely.

The anterior end, the head of the mandible, is greatly thickened into a three-sided pyramidal mass, the truncate apex of which forms the articulation surface. Its deep-yellow color contrasts strongly with the pale-yellow, thin, shell-like remainder of the mandible. Filling the space between the upper inner faces of these pyramids, is the very strong transverse muscle, the contraction of which separates the mandibular processes. A strongly marked transverse groove, dividing the superior adductor of the mandible, corresponds to the fold in the mandible as seen in *Aeolidia* from Waddell Creek Reef.

The dorso-anterior face of the pyramidal head is slightly convex and forms the insertion of the strong transverse muscle. Its posterior margin is prolonged upward and backward into a thin chitinous membrane forming the roof of the oral cavity. The posterior ventral face forms the lower anterior boundary of the oral cavity. From it and the lower anterior face arises the masticatory process as a thickened ridge curving downward and backward. Its margin is smooth throughout. From its outer surface near the margin is inserted the cuticular membrane of the mouth tube.

Total length of the mandible 1.686 mm., maximum width of the mandible 1.225 mm., length of the margin mandible 1.225 mm.

*Radula* (pl. 72, figs. 13, 14). The younger portion of the radula is parallel to the long axis of the mandible, the anterior older portion curving downward. The radula is uniserial with 24 teeth and one just indicated in the sheath, pectiniform, strongly arched, the dorsal arch bearing closely set, narrow, pointed denticles, the median one one-half to one-third the length of the others, but broader and forming a short triangle in outline directed upward and backward. The next adjacent denticles flanking the median one are also shorter, the succeeding ones rapidly lengthening so that the whole



tooth is emarginate, 60 denticles borne by the 23rd tooth, 40 denticles borne by the first tooth. The base bearing these denticles is narrowest in the median line, and increases progressively in width toward the outer ends of the arc, a condition the reverse of that in *Spurilla braziliiana*.

Total length of radula under cover glass 1.8 mm.

Height of oldest tooth 0.153, width outside 0.210 mm.

Height of 23rd tooth 0.156, width outside 0.318 mm.

Oldest tooth  $\frac{h}{w} = \frac{.153}{.210} = \frac{1}{1.37}$

23rd tooth  $\frac{h}{w} = \frac{.156}{.318} = \frac{1}{2}$

Maximum height of base, oldest, 0.033 mm., *i.e.*, height at side

Maximum height of base, 23rd, 0.042 mm., *i.e.*, height at side

Spread of base, oldest tooth, 2.5 mm.

Spread of base, 23rd tooth, 5.0 mm.

*Color.* General body color translucent gray becoming cream on the dorsum. The cerata appear very bright because of surface coloring. To attain this effect, a wash of chrome orange was used. The liver branches, raw umber in color, are not very distinct terminating against the white tips which have inside a small distinct cone of white. A brilliant orange-vermilion is found in streaks on the edges of the cerata, forming a marginal boundary, being most pronounced on the inner edges of the median line. A frosting of white occurs at the base of the tips. (Pl. 62, figs. 4, 5, 6.)

The rhinophores are the most striking feature, first attracting attention in the tide pools by their brilliancy. The laminae are orange-vermilion, which contrasts sharply with the clavus and stalk. The full leaves, with the short intermediate ones, being thick and ridge-like, make a mass of color below the encrusting white of the tips.

A pale spot of vermilion occurs on the head and over the heart region, becoming pronounced in specimens of deep coloring.

An encrustation of white occurs on the outer half of the anterior tentacles and the anterior margin of the foot. From the tentacles, the white may extend to the anterior head, back between the rhinophores, replacing in paler specimens the spots of bright color.

*Eyes* quite conspicuous and far back.

*Mouth* anterior of the upper lip of the anterior foot groove. The opening, three-pointed under the anterior head margin.

*Anus opening* inconspicuous above the interval between the inner ends of the fifth and sixth rows on the upper right side of the slope of the cardiac elevation.

*Renal pore* slightly anterior of the end of the fifth row of cerata.

*Reproductive openings.* The anterior ends of the sixth and seventh cerata rows are above the external openings, terminating as two low ridges.

*Cerata.* Seventeen oblique rows on the left side as distinguished by the outer ends of the rows. The median dorsum is free from cerata, widely so to behind the car-

diac elevation. The inner ends of the rows approach each other, but even the last ones leave a bare strip in the median line. In *Aeolidia papillosa* the rows appear to meet in the tail region, which is thus entirely covered. The rows run at an acute angle outward and forward, much more so than in *Aeolidia papillosa* and thus each row is quite long. The cerata in front of the rhinophores are closely crowded and somewhat obscure, not being arranged in a single series. The inner end of the first row of the left side is just behind the outside base of the rhinophore. From a slightly elevated crescentic base the short flattened cerata arise closely crowded together. The outer end of the series is lateral, immediately behind the anterior tentacle; 20 to 22 cerata form the first series.

The second series is made up of some 16 cerata arranged in a fairly regular double row, the upper end of which is in line with the rhinophore base and close behind the first. It terminates below the first, close behind the anterior tentacle on the side of the head.

The 17 cerata of the third row are arranged in a single series parallel with the first two, the outermost cerata being reduced at the end to slight knobs upon a narrow low ridge. Seventeen rows of cerata on the left side, the greatest number in each row being 22. The same number are present on the right side. The first and second rows are closely crowded in front of and lateral to the rhinophores. The post-cardiac cerata are not uniformly distributed in rows, but are arranged in groups, six or seven in number. Each group shows at least two rows at the median end. Laterally the number of rows seems to increase by one. They run at an acute angle outward and forward; when clipped on alcoholic specimens, an arrangement into closely inverted V-shaped groups is revealed.

The anterior ends of the sixth and seventh rows continue above the external reproductive opening as two low ridges on the right side, the inner ends of the rows being far back; the sixth row being 8.4 mm. long.

The anal opening is inconspicuous above the interval between the ends of the fifth and sixth rows on the upper right side on the slope of the cardiac elevation.

The strongly contracted rhinophore shows its laminate condition with difficulty, the laminae apparently not being so erect as shown in the colored figure.

Preserved specimen, No. 5. Length over all 9.6 mm., width 4.4 mm.; length of foot 7.3 mm., width of foot 3.0 mm.

Mouth partially everted, tube puffed out in a rounded disk. Anterior margin of foot bilabiate, its angles scarcely prominent, laid back in contraction, but evidently well developed in life. Anterior tentacles contracted into rounded conical prominences. Rhinophores strongly contracted, apparently perfoliate but not certain without dissection. Cerata in closely set oblique rows, leaving the mid-dorsum free.

*Dimensions* of living specimens. first (1904) specimen. Body length, crawling, 25 mm., width 6 mm., height 3.5 mm., foot width 6 mm., angles of foot tip to tip 7.5 mm., anterior tentacles length 6 mm., tip to tip 11.5 mm. rhinophore height 2.5 mm.

Living specimen of 1932 had the following measurements: body length, crawling, 23.3 mm.; foot anterior-end width 5 mm., produced at angles, width 9.1 mm., length

(floating) 20 mm., maximum width 5.7 mm.; anterior tentacles length 3 mm.; rhinophores length 4.3 mm.

Alcoholic specimen. Foot length 14.5 mm., width 4.2 mm.; body height at heart 5.4 mm., width 7.3 mm.

Two alcoholic specimens were used for dissections, designated as No. 5 and No. 6. Number 6 is a large specimen, photographed in 1928: length of foot 14.5 mm., width at anterior end 4.2 mm.; height in cardiac region 5.4 mm., width of body 7.3 mm. Animal moderately contracted, tail flexed, mouth region somewhat everted, rhinophores strongly contracted into conical knobs. Anterior tentacles scarcely distinguished at the angles of a broad shield-like portion, in the center of which is the everted mouth tube. Anterior margin of foot rounded, bilabiate, no median notch, its outer angles prolonged into short angular tips.

Range of length of specimens from 20 to 30 mm.

*Habitat.* Rare, the total number of specimens taken being six; possibly there were two additional ones, for much of the author's material was lost in the earthquake of 1906. The data for the six specimens recorded and used in these descriptions are as follows: in July, 1904, at Cabrillo Point, the first was taken and studied with full drawings and notes; 1908, 1911, and June, 1932, specimens were taken by the author at Point Pinos. At the latter place and in June, 1932, G. MacGinitie took one floating on the surface of the Large Pool. In July, 1941, one specimen is recorded from Point Pinos by R. Bolin. The painting was completed from the living specimens taken in 1932 and 1941.



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## PLATE 1

Figs. 1-5. *Gastropteron pacificum* Bergh  
(Pages 2-6)

- Fig. 1. Specimen fully extended, parapodia in normal position. The inrolled tube from the head shield, the foot, and flecks of color arranged in rows are definitely shown.  $\times 10$ . Painting by Anna B. Nash.
- Fig. 2. Front view, right parapodium thrown to one side, showing the broad shield with the siphon-like tube and the mouth below. Body rounded, high, the entire gill exposed; below it the seminal groove; above, the anal papilla and a very slight mantle fold.  $\times 5$ .
- Fig. 3. Drawing of the same specimen showing the right side at a different angle. The pointed posterior extremity shown; an oblique view of the head tube; free tip of gill concealed.  $\times 5$ .
- Fig. 4. Made with a camera lucida; alcoholic specimen showing the ventral surface of the body and the head parts; parapodia continuous with the foot.  $\times 5$ .
- Fig. 5. Two figures of the shell.  $\times 55$ .





## PLATE 2

Figs. 1-3. *Navanax inermis* (Cooper)

(Pages 9-11)

- Fig. 1. Water color study of a living animal, 100 mm. in length. Drawing made from a photograph. Specimen colored in shades of brown and yellow; parapodia adorned with broken lines of cerulean blue, marginal edge of bright orange.  $\times 1.3$ .
- Fig. 2. Ventral surface of the same specimen showing very characteristic spotting of color, foot rounded up into parapodia, under side of head shield inrolled into rhinophore-like projections, surface of labial palps armed with blunt tactile hairs.  $\times 1.1$ .
- Fig. 3. Drawing of a deep-brown specimen. The majority of *Navanax inermis* are very dark in coloring. All have a brilliant blue sheen over the surface; velvet-like, the head and tail lobes glow with a dark luster. The lines and spots adorning them are always a straw yellow and the patterns are constant, varying only in amount of color.  $\times 1.3$ .

Fig. 4. *Aglaja diomedea* (Bergh)

(Pages 6-9)

- Fig. 4. Painting made from life; body color a rich maroon red, pale within the parapodia; spots a pale yellow. Anterior angles of the foot produced into blunt processes; angles of cephalic disk thickened and rounded into rhinophore-like prominences. The left caudal lobe is lengthened into a slender flagellum.  $\times 4.4$ . Painting by Anna B. Nash.



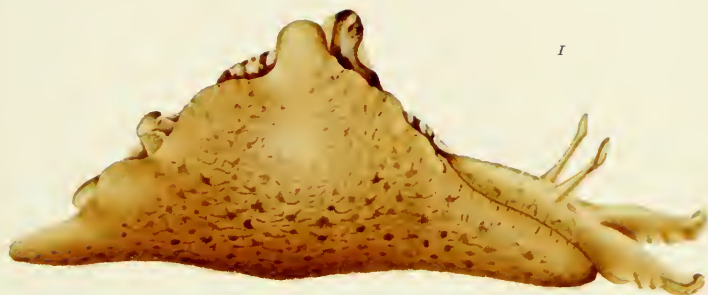
## PLATE 3

**Figs. 1-3. *Aplysia californica* Cooper**  
(Pages 12-19)

- Fig. 1. Figure painted from living specimen of brown coloring; profile of right side. Found feeding upon *Laminaria farlowii* and other large-growing algae of brown color. Specimen 240 mm. in length.
- Fig. 2. Painting made of right side, an oblique view; specimen of exceedingly dark-red to deep-purple coloring. The broad-leafed alga, *Gigartina corymbifera*, is similar in color; the genus *Iridophycus* has a color and iridescence repeated on the animal in brilliance. Specimen 260 mm. in length.
- Fig. 3. Specimen from Elkhorn Slough, Monterey Bay. Such gray-green animals as this with brown markings, find food in the *Fucus* zone. The genus *Desmarestia* of the marine algae has similar shades of brown. Specimen 400 mm. in length.
- In specimens of all colorings, the inner parapodia are marked by patterns of dark with an encrusting of white. This is also carried as a line on the edges of the parapodia and siphon. The dark spots, on the lateral surface, form a center from which radiate a network of fine lines. These characters are constant on all that have been collected.

**Fig. 4. *Phyllaplysia taylori* Dall**  
(Pages 19-27)

- Fig. 4. The painting is of a living animal taken at Newport Bay, found feeding upon Bryozoa on the leaves of *Zostera*. The vivid green matches perfectly the color and the parallel markings of *Zostera*, its habitat; clinging to the leaf, stretched full length, the shadow alone is visible. The cross markings may be present or absent, but the brilliant blue tips of the rhinophore and tail are constant.  $\times 3$ .



## PLATE 4

Figs. 1, 2. **Elysia bedeckta** MacFarland, new species  
(Pages 50-54)

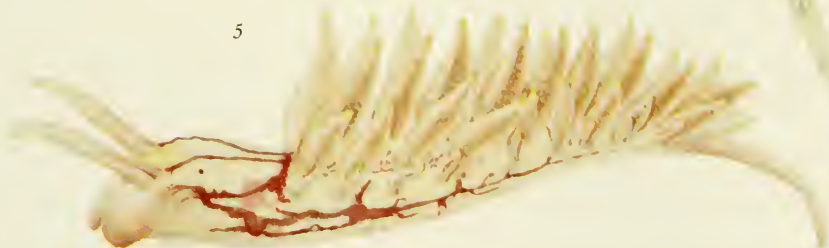
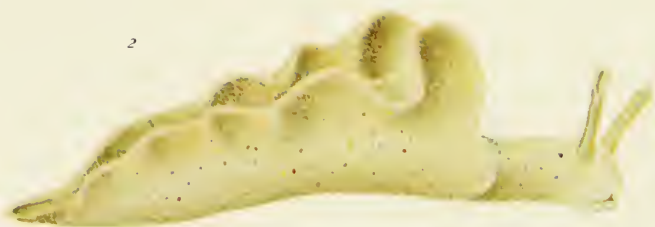
- Fig. 1. Dorsal view, parapodia thrown open exposing the heart elevation; the paired vascular ridges; dendritic ramifications of green below the surface terminating in thickened blunt endings at the surface. The texture of the integument is similar to that of the *Codium fragile* upon which it is frequently found.  $\times 3$ .
- Fig. 2. Right side with turned head showing the mouth; thick parapodia with rounded edges, a dense network of green venations and the many brilliant colored spots are all characteristic of this species.  $\times 3.5$ .

Fig. 3. **Hermaea ornata** MacFarland, new species  
(Pages 38-42)

- Fig. 3. View of left side, tail arranged to show the dorsal surface; detail of left rhinophore is clear. Liver venations are carefully drawn showing the patterns of the arborescent system of green branches, below the most transparent integument, which ramify to the cerata and throughout the body. *Bryopsis* habitat.  $\times 14$ .

Figs. 4, 5. **Hermaeina oliviae** MacFarland, new species  
(Pages 43-46)

- Fig. 4. Ventral view showing details of head parts, narrow foot, cerata groups. Figure drawn from alcoholic specimen, coloring from life.  $\times 9$ .
- Fig. 5. Figure from life, left side; left rhinophore, yellow spot between rhinophores, conspicuous widened liver branches which send their terminations backward to the cerata in which they show as nodules near the surface.  $\times 12$ .





## PLATE 5

**Figs. 1-5. *Pleurobranchus californicus denticulatus* MacFarland, new subspecies**  
(Pages 84-89)

- Fig. 1. Dorsal view, drawn and painted from living specimen. Largest taken, 1894. Monterey Bay. Drawn by Anna B. Nash.  $\times 2.5$ .  
Fig. 2. Front view of same specimen. Reduction from original figure. Drawn by Anna B. Nash.  $\times 2.2$ .  
Fig. 3. Figure of the entire right side of living animal; showing gill, reproductive opening, details of head, rhinophore, and frontal veil. Drawn by Anna B. Nash.  $\times 3.1$ .  
Fig. 4. Detail of gill; shows lower third of one pinnule, the rounded tubercles at the juncture with the rachis, the smaller tubercles at the juncture of the platelet with the pinnule. Drawn by Anna B. Nash.  $\times 1.5$ .  
Fig. 5. Egg band in a coil, drawn as deposited. Drawn by Anna B. Nash.  $\times 1.4$ .

**Figs. 6-8. *Tylodina fungina* Gabb**  
(Pages 56-68)

- Fig. 6. Dorsal view, specimen crawling; 38 mm. in over-all length, thatched structure of the shell well shown. Paintings from life of specimen taken at Newport Bay.  $\times 3$ .  
Fig. 7. Drawing of an oblique view from the side; from the sole of the foot to the apex of the shell 8.5 mm.; head parts well shown, bilabiate anterior margin separated from the foot margin by a notch, gill clear, with its pinnules under the edge of the shell; seminal groove lateral to, and anterior to the right rhinophore.  $\times 3$ .  
Fig. 8. Camera-lucida drawing of living animal eating a sponge. About  $\times 1$ .



## PLATE 6

Figs. 1, 2. **Pleurobranchus californicus** Dall

(Pages 82-84)

- Fig. 1. Dorsal view of type shell; Oldroyd Collection, Stanford University. Spiral nucleus, lines of growth, transparency, all clearly shown.  $\times 4.5$ .  
Fig. 2. Ventral side of same shell is shown. Details of the sculpture very clear.  $\times 4.5$ .

Figs. 3-7. **Pleurobranchus strongi** MacFarland, new species

(Pages 89-93)

Photographs of four mounted shells; one specimen taken at San Pedro, three taken at Point Pinos, Monterey Bay.

- Fig. 3. Type shell from specimen collected by A. M. Strong at White's Point, San Pedro.  $\times 6.1$ .  
Fig. 4. Enlargement of spire of mount, showing the turns.  $\times 27$ .  
Fig. 5. Photograph of shell mount, dorsal side, umbo broken, growth lines clear. From Point Pinos.  $\times 5$ .  
Fig. 6. Photograph of shell mount. Shell elongate in outline, white and thin; small spiral nucleus somewhat recurved, central portion convex, growth lines very distinct. The sculpture similar, more pronounced, than in type. From Point Pinos.  $\times 5$ .  
Fig. 7. The shell mount is from a specimen collected at Point Pinos, 1941, by Betty Blagg.  $\times 5.3$ .

Fig. 8. **Aglaja diomedea** (Bergh)

(Pages 6-9)

- Fig. 8. An unusual shell, mounted, dorsal side uppermost. The apex arches over to the ventral side showing through the transparent shell as a dark shadow, growth lines strongly marked. The tip, broken, indicated by dotted line, is mounted on the same slide. Collected by M. H. Hatch, 1940, in Puget Sound.  $\times 10$ .

Fig. 9. **Aclesia rickettsi** MacFarland, new species

(Pages 27-32)

- Fig. 9. Photograph of alcoholic specimen which is the type of the new species. The right side with the genital groove is shown. The surface of the dorsum bearing tubercles, head with four tentacles, all branching irregularly, give the animal a most unusual appearance. Two specimens were collected by Ricketts at Point Lobos on Espíritu Santo Island, Sea of Cortez.  $\times 2$ .

Figs. 10, 11. **Navanax inermis** (Cooper)

(Pages 9-11)

- Fig. 10. Dorsal view of specimen from Elkhorn Slough, Monterey Bay. Details in the distribution of pigment are shown. Photograph by the author.  $\times 1$ .  
Fig. 11. Variations in the distribution of amount of color are shown. The patterns of the colors are constant, but the amount of pigment varies within a wide range.  $\times 6$ .





**Figs. 12-13a. *Tyrodina fungina* Gabb**

(Pages 56-68)

- Fig. 12. Dorsal view of shell from Oldroyd Collection, No. 842, Stanford University. Shell entirely free of traces of the periostracum.  $\times 1.6$ .
- Fig. 13. Ventral view of shell from specimen dissected by the author. From Newport Bay.  $\times 1$ .
- Fig. 13a. Embryonic tip of the same shell, greatly enlarged. The surface just below the tip is smooth, glows and glistens; rough surface of the periostracum below. Photographs by the author.  $\times 7$ .

**Fig. 14. *Dolabella californica* Stearns**

(Pages 32-37)

- Fig. 14. A green-spotted specimen taken at San Gabriel Bay on Espiritu Santo Island. (Sea of Cortez, p. 542.)
- This specimen, designated as No. 26, was photographed by the author as shown in this figure.  $\times 1.5$ .

**Figs. 15-17. *Aplysia californica* Cooper**

(Pages 12-19)

- Fig. 15. Print shows top view of head parts; profile of side and spotting inside of parapodia. The dead-white lines on anterior parapodia are pronounced, seminal groove, too, is clear; also the network on the sides which radiate from dark central spots.  $\times \frac{1}{6}$ .
- Fig. 16. Shell dissected out from 300 mm.-long specimen. Two dorsal views are shown by the author. This figure, broadly hatchet-shaped, membranous, translucent; calcification very slight; accessory plate arising close from the shell, apex directed backward.  $\times \frac{1}{2}$ .
- Fig. 17. This shows more clearly the central area of the shell, bordered by an amber zone; outside is a broader transparent one. Magnification slightly less than figure 16.  $\times 4$ .



## PLATE 7

Figs. 1-10. *Gastropteron pacificum* Bergh

(Pages 2-6)

- Fig. 1. Reproductive system, ventral view, outer parts; the small hermaphroditic duct dilates into a long segment; *b* marks a sharp turn, *c* a striking loop; a spindle-shaped ampulla follows proximal to the entrance, *a*, into the preputium near the duct of the nidamental-albumen glands. The spermatheca opens into the vestibulum genital by a short duct at its proximal end.  $\times 16$ .
- Fig. 2. The preputium is represented as seen from above; a long roomy sac, 1.7 mm.  $\times .07$  mm., a short neck at the distal end is shown, at which point the retractor muscle is attached; the duct, at the proximal end of the tubular, convoluted prostatic gland, enters midway of the preputial wall.  $\times 16$ .
- Fig. 3. This figure represents the dorsal wall of the preputium removed; a calyciform structure, attached to the dorsal wall, is disclosed, surrounding, at its base, the opening of the prostate gland. A plate-like collar, terminating in an undulating margin, bears a series of small pointed papillae.  $\times 24$ .
- Fig. 4. The thin ventral wall of the preputium is cut away, disclosing the narrow canal of the preputial sac. The seminal groove under the dorsal ridge is prolonged inward, three low folds run parallel; the dorsal ridge shows a transversely marked surface terminated by a bifurcation.  $\times 24$ .
- Fig. 5. First lateral tooth of the radula, front view.  $\times 180$ .
- Fig. 6. Outer face of first lateral.  $\times 180$ .
- Fig. 7. Row of laterals, showing the large one in side view.  $\times 180$ .
- Fig. 8. Outer lateral, long slender hook.  $\times 180$ .
- Fig. 9. Rodlets from the armature of the mandible.  $\times 250$ .
- Fig. 10. Outline of mandibles.  $\times 150$ .

Figs. 11-14. *Aglaja diomedea* (Bergh)

(Pages 6-9)

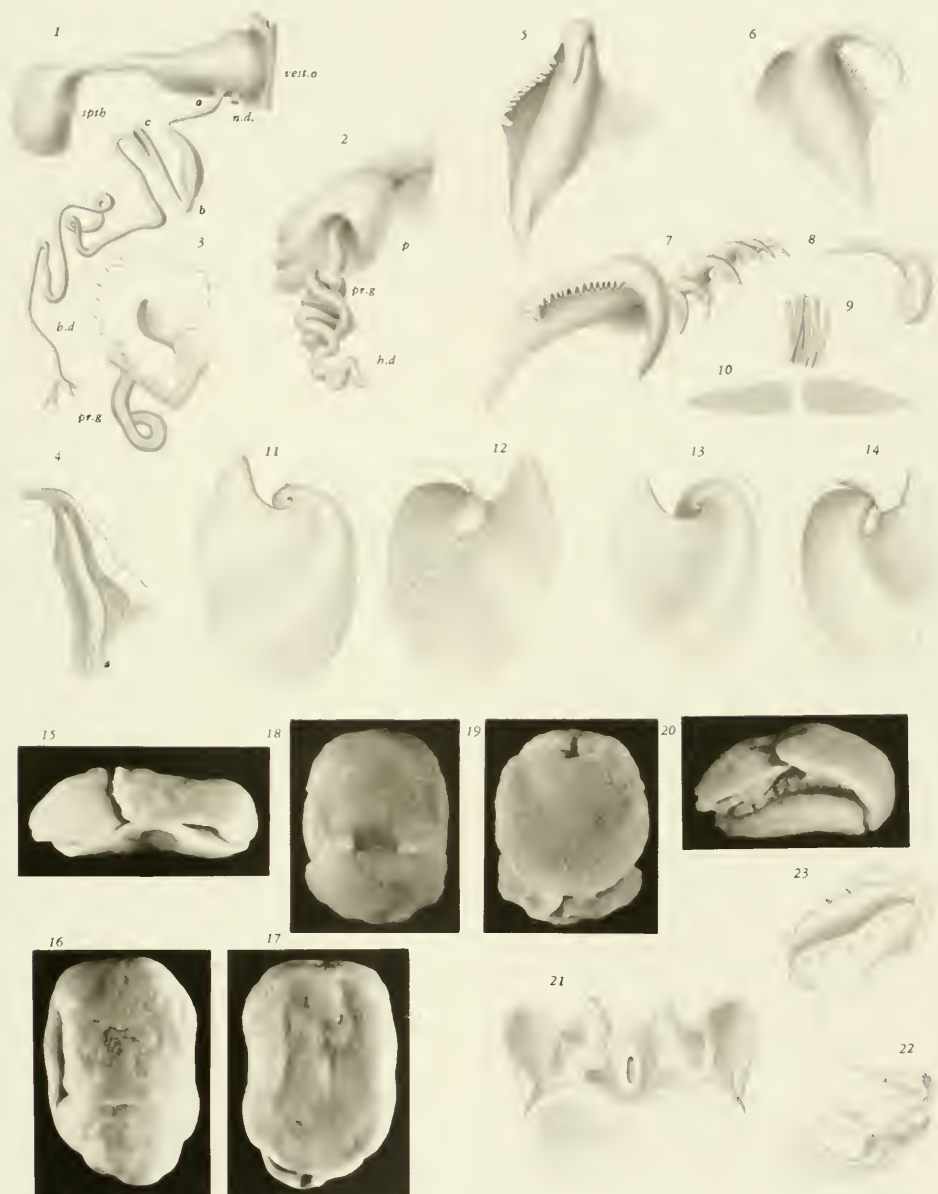
- Fig. 11. Camera lucida drawing of shell; *Aglaja diomedea* from False Bay, San Juan Island, Puget Sound; dorsal view of calcified shell. Size 5.5  $\times$  7.5 mm.  $\times 5.3$ .
- Fig. 12. Ventral view, same specimen. Collected by H. J. Snook.  $\times 3$ .
- Fig. 13. Small specimen of *Aglaja diomedea* from Drakes Bay. Dorsal view. Size, 3  $\times$  4 mm.  $\times 8.5$ .
- Fig. 14. Ventral view, same specimen; camera-lucida drawing of shell. Jane Westfall, collector.  $\times 8.5$ .

Figs. 15-20. *Philine bakeri* Dall

(Pages 1-2)

Photographs of alcoholic specimens.

- Fig. 15. View of right side, large specimen from La Jolla, California.  $\times 1$ .
- Fig. 16. Dorsal view of same specimen.  $\times 1$ .
- Fig. 17. Ventral side, same specimen.  $\times 1.9$ .
- Fig. 18. Dorsum, smaller specimen, same habitat.  $\times 1$ .
- Fig. 19. Ventral, small specimen.  $\times 1$ .
- Fig. 20. Right side, showing gill. An encrusting of white on the surface of the integument gives a roughened texture on this specimen.  $\times 1$ .





Figs. 21-23. *Navanax inermis* (Cooper)

(Pages 9-11)

- Fig. 21. Head of *Navanax*; drawing made from living specimen, direct view of front, as seen from below. Head shield above, outer angles produced into short, rolled, scroll-like tentacles (or rhinophores). Labial palps, arising from the inner side of these, present a flat rounded surface covered by hair-like processes, intermingled with minute points. These also cover the thickened, anterior rolled edges of the tentacles. Mouth opening with thickened lips, in full view.  $\times 1.8$ .
- Fig. 22. Same head in oblique view from above. Labial palps present a variety in form, view from different angles. These are presented shield-like as the animal follows up the channels of the mud flats at out-going tide.  $\times 1.3$ .
- Fig. 23. Everted mouth opening shows low blunt papillae, largely on the upper half of the margin. These are extended, showing clearly in the swallowing act. They are either gustatory or tactile or both.  $\times 12$ .

## PLATE 8

Figs. 1-15. *Aplysia californica* Cooper  
(Pages 12-19)

- Fig. 1. Nine outermost teeth; left side, first three showing wing on lower outer margin of base; outermost rudimentary.  $\times 45$ .
- Fig. 2. Nineteenth tooth from second row, slightly oblique; irregularity of denticles clearly shown.  $\times 45$ .
- Fig. 3. Ninth and tenth teeth of the 40th row, fine denticles toward tip of cusp, wing slight at tip of base.  $\times 45$ .
- Fig. 4. Median tooth with expanded posterior angles of base, deep notch on anterior margin, large cusp directed upward and backward; one lateral on the right, two on the left side; body stout with base directed obliquely outward, showing the expanded margin as a thin overlapping wing.  $\times 45$ .
- Fig. 5. Outer face of isolated lateral from the left side, one large denticle.  $\times 45$ .
- Fig. 6. Inner face in profile, on left side, denticles more regular in form.  $\times 45$ .
- Fig. 7. Inner face, left, showing irregularity of base-line margin.  $\times 45$ .
- Fig. 8. Isolated tooth from the left side showing clearly the thin wing on outer margin of base.  $\times 45$ .
- Fig. 9. A lateral from the right side of the radula, presenting the outer face with a long sharply pointed cusp, irregular indentation.  $\times 45$ .
- Fig. 10. Palatal spine from the cuticular investment of the folds of the pharyngeal groove.  $\times 309$ .
- Fig. 11. Outline of mandible; *a*, anterior edge.
- Fig. 12. Imprint of bases of mandible rodlets, posterior part.  $\times 312$ .
- Fig. 13. Sectional drawing which shows the development of the mandible rodlets; *a*, rodlet epithelium; *b*, rodlets; *c*, homogeneous chitin; *d*, upper epithelium of sulcus.  $\times 111$ .
- Fig. 14. Fully developed rodlets of mandible before zone of homogeneous chitin is reached.  $\times 100$ .
- Fig. 15. Distal ends of rodlets.  $\times 380$ .

Figs. 16-25. *Aclesia rickettsi* MacFarland, new species  
(Pages 27-32)

- Fig. 16. A young row of the radula which is broad, deeply grooved in mid-line; base of median, trapezoidal in outline, posterior margin concave, rarely a third small denticle on median point; laterals show base parallel to outer margin of median, a stout median hook curving backwards, smooth on inner margin, outer margin with a triangular denticle, beyond it a broad angular one; successive laterals show a lengthening and rounding of the cusp.  $\times 180$ .
- Fig. 17. The outer five laterals are pictured from the 12th row showing compressed, long, slender hooks from a shortened base.  $\times 180$ .
- Fig. 18. The inner face of a large fourth lateral from the 19th row, wing on outer margin, smooth inner margin.  $\times 180$ .
- Fig. 19. First lateral, outer face, central cusp angular, oblique view of wing.  $\times 180$ .
- Fig. 20. Profile of fifth lateral, 20th row, rounded hump on posterior margin of base.  $\times 180$ .
- Fig. 21. View from above of two teeth, eight and nine from the eighth row, cusp and denticles long.  $\times 180$ .
- Fig. 22. Imprints of rodlet bases.  $\times 180$ .
- Fig. 23. Rodlets from armature of anterior margin of mandible.  $\times 180$ .
- Fig. 24. Diagrammatic figure which depicts the mouth opening at the anterior end of the oesophagus, *a*, groove, *b*, extends backward from the mouth; *m*, mandibles on either side; *d*, palatal folds of the pharyngeal integument bordering the widened opening; *e*, bands of cuticular spines cover the folds.
- Fig. 25. Palatal spines, flat pointed hooks.  $\times 180$ .







Figs. 26-32. *Dolabella californica* Stearns

(Pages 32-37)

- Fig. 26. Twenty-sixth row from radula showing a very narrow rachis with a nearly rudimentary plate having a small cusp; laterals, one on left, four on right side; hook of first pointed, others increasing in length, rounded, increasingly long and blunt.  $\times 76$ .
- Fig. 27. Outer face of isolated lateral, the 40th from the third row; hook long, flattened above, edge thin; roughened along base margin.  $\times 76$ .
- Fig. 28. Outer four laterals of left side.  $\times 76$ .
- Fig. 29. Outline of mandible plate.  $\times 10$ .
- Fig. 30. Rodlets from mandibular armature; prismatic in form.  $\times 212$ .
- Fig. 31. Imprints of bases of rodlets.  $\times 212$ .
- Fig. 32. Two spines from the palatal plates in front, and lateral to the oesophageal opening; large basal cell which has produced the spine, which is composed of layers of chitin showing irregular partitions; posterior face slightly grooved.  $\times 68$ .

Figs. 33-39. *Phyllaplysia taylori* Dall

(Pages 19-27)

- Fig. 33. Median tooth and two laterals from row 25 of radula; median tooth smaller than the laterals, base trapezoidal in form, limb divergent; the recurved short hook shows shallow grooves terminating in the rounded denticles. The laterals display very long, thin, broad cusps with a denticle on either side, base set obliquely, widened at the posterior margin and a wing on the outer margin.  $\times 132$ .
- Fig. 34. First lateral from oldest part of radula displays a cusp worn short.  $\times 132$ .
- Fig. 35. Tenth lateral, under the sheath on left side, has a base high in the center curving backward to the margins; edge of long cusp shows clefts.  $\times 132$ .
- Fig. 36. Three displaced laterals, the last in the row, are under the sheath; base thickened into a central ridge as it recurves into the long cusp and terminates in a point.  $\times 132$ .
- Fig. 37. Drawing through a serial section showing two teeth in profile, embedded in the cuticle.  $\times 198$ .
- Fig. 38. An unusually favorable cross section of the mouth tube which passes through both mandible plates; the drawing shows, *a*, the plates almost in contact at their tips dorsally; *b*, on the ventral side of the tube, the bases are separated by one-third their length, between, a thin cuticle covers the epithelium of the cavity. The extent of the rodlets from each plate is shown, one from each specialized epithelial cell.  $\times 8$ .
- Fig. 39. Rodlets under a high magnification; *a*, epithelial cells producing the cuticular layer; *b*, homogeneous cuticle; *c*, rodlets developed from this layer; average length of rodlets, .036 mm.  $\times 68$ .

## PLATE 9

Figs. 1-7. *Aplysia californica* Cooper

(Pages 12-19)

- Fig. 1. Reproductive system. View from above, the parts but slightly separated. The elliptical genital complex shows the convolutions of the albumen gland and the broader windings of the nidamental gland. The elongate spermatocyst lies upon the left anterior margin. The large hermaphroditic duct is irregularly looped and somewhat twisted as it passes forward to the vulvar opening. Figures *a* and *b* are outlines of cross sections of the large hermaphroditic duct at two points, *a-a*, *b-b*, showing the channels followed by the eggs and sperm to the external opening.  $\times 1.5$ .
- Fig. 2. A diagrammatic figure made from the study of serial sections through the genital complex. The relation of the parts within are shown as if viewed from the ventral side. The fertilization chamber receives the broad duct of the albumen gland, *alb. gl.*, and connects broadly with the nidamental gland. At its distal end, the fertilization chamber passes into the vaginal duct as it receives the duct of the spermatocyst, *spc.*, and enters the large hermaphroditic duct.  $\times 2$ .
- Fig. 3. Outer face of the glans is shown, free from the sheath, two-thirds of its length. The glans is rounded and broad at the base, becoming narrowed and flattened midway to the end. On the ventral surface is a deep furrow from base to tip, the spermatic groove. This has a filled margin above it, a row of low papillae below.  $\times 2$ .
- Fig. 4. Outlines of three sections across the glans; *a*, near the base where the diameter is 7.3 mm. and the spermatic groove is deepest, the contour rounded; *b*, represents a section midway, groove shallower, the preputial wall cut across; *c*, the pointed, flattened end, the groove extending to the tip. In each drawing the spermatic groove, *sp. gr.*, is indicated.  $\times 3$ .
- Fig. 5. Glans of large specimen, outer face, life size, camera-lucida drawing; 57 mm. overall in length; 9 mm. diameter at the base, tip flattened.  $\times 1$ .
- Fig. 6. Drawing made to show the palatal folds which are described in some detail. Folds are shown on the right half of the pharyngeal bulb. These are bright yellow and stand out with distinction, merging into the folds of the oesophagus. A prolongation of the oesophagus at its entrance into the bulb forms a median groove extending behind the mandibles and above the radula, and is limited by a folded dorso-lateral thickening on either side.  $\times 2$ .
- Fig. 7. An outline drawing of the shell of a young specimen of *Aplysia californica*, 50 mm. in length. It is hatchet-shaped, membranous, with the outer zone clear and transparent, the inner zone pale yellow; delicate lines arise from the apex. At the widest point, *a-a*, 10.7 mm.  $\times 2.2$ .

Figs. 8-12. *Aclesia rickettsi* MacFarland, new species

(Pages 27-32)

- Fig. 8. Reproductive system. Dorsal view of the parts but slightly separated.  $\times 4.6$ .
- Fig. 9. Same dissection seen in ventral view. The convoluted portion of the small hermaphroditic duct, *h.d.*, upon reaching the anterior genital mass makes several loops, passes to the ventral border where it branches into two divisions: the anterior one receiving the duct of the spermatocyst, *spc.*, the other entering the fertilization chamber; the relations are best studied from serial sections. This chamber receives the broad opening of the albumen gland and expands into the lumen of the broad mucous gland loops, continues beyond this as the oviductal portion of the large hermaphroditic duct, *h. d.* This is broad, somewhat flattened, and twisted spirally as it passes to the external opening. Before this is reached, it forms a close loop forward and upward, passing to the vulvar opening with a dilated vaginal segment. This may correspond to the bursa seminalis.  $\times 4.6$ .
- Fig. 10. Figure of the gill, showing one side with an indication of the other side at the tip. Ten to 12 lamellae are borne upon a triangular plate attached to the left wall of the branchial cavity; *a* marks the hinder mantle margin which is thickened, glandular, and pigmented; *os.*, osphradium close under the edge of the anterior attachment of the gill.  $\times 2.5$ .





- Fig. 11. Drawing of head of an alcoholic specimen shows the anterior tentacles, wide inrolled plates; mouth with thickened lips, prolonged downward and outward in thickened lobes, united above to the head but free at the tips. This process is characteristic of the genus *Aclesia*.  $\times 8$ .
- Fig. 12. Rhinophores, deeply grooved externally; surface with papillae.  $\times 8$ .

**Figs. 13, 14. *Dolabella californica* Stearns**

(Pages 32-37)

- Fig. 13. Outer face of the verge. Dissected from the penis sheath; contracted to less than one-half the full length of the sheath. A broad wing-like expansion arising near the base, continues distally to near the tip and is inrolled over the external spermiatic groove.  $\times 2.7$ . An outline is figured of a section from *b* to *b*.
- Fig. 14. The inner face shows the spermiatic groove continued to the bluntly pointed tip. The lower margin of the furrow is expanded as a prominent flattened ridge, the groove narrower and deeper.  $\times 2.7$ . An outline is figured of a section from *a* to *a*.

**Fig. 15. *Phyllaplysia taylori* Dall**

(Pages 19-27)

- Fig. 15. Reproductive system. These organs occupy a central position in the body cavity parallel to the long axis of the body, being 22 mm. in extent; two-thirds of the length of the entire body. The system is composed of the ovotestis, small hermaphroditic duct, adnexed genital mass, spermatocyst with its duct, large hermaphroditic duct, spermatheca, vestibular glands, external spermiatic groove, penis with its sheath.  $\times 3.3$ .
- The lettered abbreviations, designating the parts, are as in all reproductive figures of the Aplysiidæ.



## PLATE 10

Figs. 1-5. *Hermaea ornata* MacFarland, new species

(Pages 38-42)

- Fig. 1. Four teeth at the angle seen obliquely; the dorsal groove with thin margins and thickened prolongations, fitting closely the base of the following tooth.  $\times 312$ .
- Fig. 2. Two teeth from the younger end of the radula show the square base, a groove on the ventral side not visible; the narrow blade fits closely the groove below.  $\times 312$ .
- Fig. 3. The coiled end, at the tip of the radula, containing the oldest teeth; the ninth tooth from the end to the 19th with shorter bases than elsewhere in the radula.  $\times 650$ .
- Fig. 4. View from directly above; a single tooth under the sheath. The groove, extending three-fourths its length, rounded downward and backward to the base.  $\times 386$ .
- Fig. 5. Cross section in outline through the center of a tooth.  $\times 386$ .

Figs. 6-11. *Hermaeina oliviae* MacFarland, new species

(Pages 43-46)

- Fig. 6. Profile of tooth, third from the angle, dorsal groove seen obliquely, denticulation on lateral margin.  $\times 320$ .
- Fig. 7. Highly magnified tip of tooth showing marginal denticles.  $\times 704$ .
- Fig. 8. Figure of the spiral terminating in the sac, which holds the oldest teeth, just below the anterior end of the radula. Those in the sac consist of the cuboidal base alone; gradually the cusp comes into view, increasing until the adult teeth are reached.  $\times 563$ .
- Fig. 9. Tooth as seen from above; the dorsal groove extending two-thirds the length of the cusp; the anterior notch and thickened projections of the base are in view.  $\times 341$ .
- Fig. 10. Ventral view of the same tooth; dorsal anterior notch carried to the base level which is prolonged into a longitudinal, median, smooth-edged cutting lamina; on either side the ventral surface is carried outward to the clearly defined, overhanging, denticulate margin extending the full length of the cusp.  $\times 341$ .
- Fig. 11. Cross section in outline through the center of a mature tooth.  $\times 312$ .

Figs. 12-15. *Elysia bedeckta* MacFarland, new species

(Pages 50-54)

- Fig. 12. Sixteenth tooth at the angle of the radula, measurements given; *c-d*, .0276 mm. length of base; *a-b*, .108 mm. total length of cusp; *a-e*, .0732 mm. length of cusp to posterior angle of base in a straight line.  $\times 515$ .
- Fig. 13. Profile view with end of base turned, showing cross section at the termination of the central groove.  $\times 350$ .
- Fig. 14. Four teeth at the angle, 15th to 18th; the 15th shows the base with central groove, rounded anterior cusp which fits under the dorsal edge of the succeeding tooth.  $\times 312$ .
- Fig. 15. Section in outline through the central part of adult tooth.  $\times 312$ .

Figs. 16-28. *Phyllobranchopsis enteromorphae* Cockerell and Eliot

(Pages 46-50)

Radula. Two radula mounts were used in the study of the teeth. These supplemented by a perfect series of 112 sections stained with heidenhain "azan" and orange G. The parts of the teeth are clearly shown in the following figures; the upper median ridge, *a*, on the anterior face, the posterior end flattened from side to side, both of these with a cutting edge. Two thin, denticulate laminae projecting backward at a divergent angle forming a wedge-shaped space into which the median lamina fits when the teeth are in approximation.





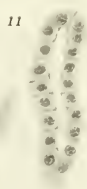
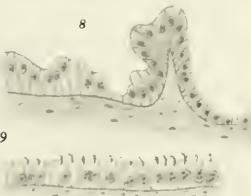
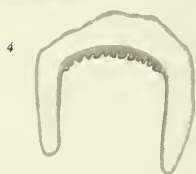
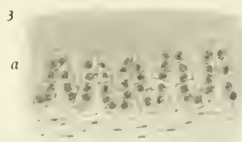
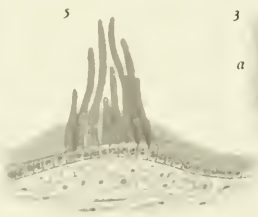
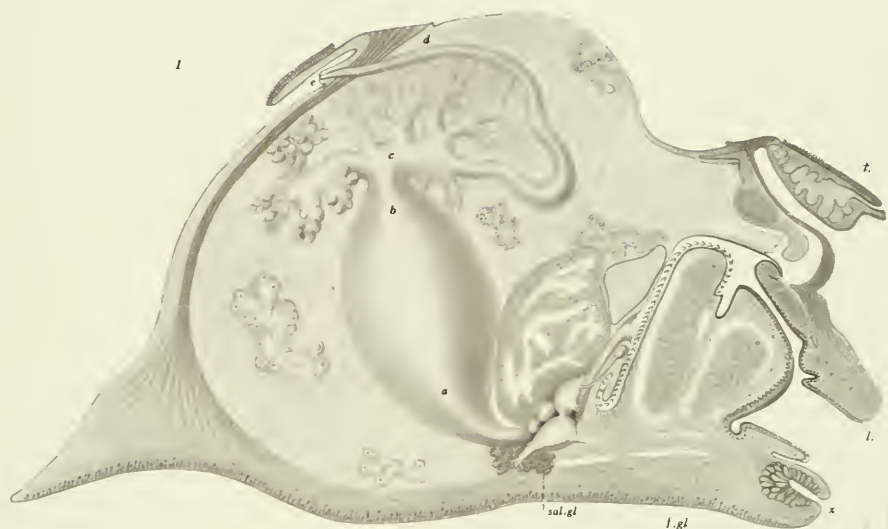
- Fig. 16. Three teeth at the angle so inclined that the groove of the base is seen on the ventral surface.
- Fig. 17. Rarely there is a cleft in the cutting edge of the posterior flattened end.  $\times 325$ .
- Fig. 18. Tooth seen obliquely, showing the attachment of the two projecting laminae on the flattened posterior end.  $\times 325$ .
- Fig. 19. Two larger teeth from the second mount are drawn; full length .096 mm., length of base .036 mm., from tip to posterior inner corner of the base .066 mm.  $\times 338$ .
- Fig. 20. Coil at the end of the radula with the oldest teeth.  $\times 185$ .
- Fig. 21. This figure shows a series of drawings of sections which are very favorable as they pass through the ventral and dorsal limbs of the radula, one above the other.  $\times 312$ .
- Section *a*, figures a transverse section of the tooth on the ventral limb; *a'* shows the tip of the tooth on the upper limb.
- Section *b* shows cross section of the ventral limb; *b'* approximate longitudinal section of the dorsal limb; each shows the relation of the thin anterior median plate of the tooth to the groove made by the denticulate laminae.
- Section *c* shows the ventral limb; *c'* the dorsal limb. Similar to *b* and *b'*.
- Section *c*, shows the ventral limb; *c'* the dorsal. Especially favorable. The ventral limb shows the denticulate laminae, thin plates inclosing the space into which fits the median, pointed smooth-edged ridge; *c'* of the dorsal limb shows all parts of the tooth.
- Fig. 22. A view of the right side of alcoholic specimen; reproductive openings, detail of rhinophore and ventral margins of foot can be seen.  $\times 10$ .
- Fig. 23. Drawing of the head parts, oblique view from below.  $\times 10$ .
- Fig. 24. Head, oblique view of rhinophores, labial palps lobes at the anterior end of foot.  $\times 10$ .
- Fig. 25. Front of head from above which shows the notch in the rhinophore, labial palps, lobes of anterior foot margin.  $\times 10$ .
- Fig. 26. A figure of the reproductive parts. From the *ov. t.*, ovotestis, arises the *s. h. d.*, small hermaphroditic duct, which widens into the *amp.*, hermaphroditic ampulla. It divides at its distal end into the *v. d.*, vas deferens, and *ov. d.*, oviduct; the first passing into the *pr.*, prostate gland; the second receives the duct of the *sph.*, spermatheca. The external opening of *p.*, preputium, and *vag.*, vagina, are side by side.  $\times 22$ .
- Fig. 27. A diagrammatic figure shows more clearly the connections of the vagina and its ducts.  $\times 22$ .
- Fig. 28. Sectional drawing from series through the reproductive parts. The duct of the spermatocyst passes into the vagina near its connection with the right ventral-posterior lobe of the mucous gland.  $\times 90$ .

## PLATE 11

Figs. 1-13. *Tylodina fungina* Gabb

(Pages 56-68)

- Fig. 1. Sagittal section through the entire body of the animal from the notch in the anterior labial margin to the tip of the tail. For the specimen used, foot length, notch to tip was 7.3 mm; width 6.7 mm; notch 1 mm. The shell measured 2.4 by 9.4 mm. Sections were cut  $40\mu$  in thickness. The figure shows clearly many details of the cuticular investment of the mouth tube. The pharyngeal bulb fills the posterior part of the mouth tube, the section passes through the mass of muscle of the bulb under the limbs of the radula with the teeth clearly in view; the oesophagus passes through the nerve ring and enters the proximal end of the muscular stomach, ventral to the kidney and dorsal to salivary glands. The visceral hump composes the remainder of the body and contains: *a*, muscular stomach; *b*, pyloric glandular stomach, terminating as it branches into, *c*, the liver acini; *d*, the large intestine reaches, *e*, the anus at the posterior dorsal tip of the body. The ovotestis and liver are so intermingled that they cannot be separated, the liver lobules and the follicles containing eggs and sperm are easily distinguished; indicated in the drawing. The heart and reproductive organs are not shown in this section.  $\times 15$ .
- Fig. 2. The cuticular lining of the mouth tube appears differently in the various parts; this figure shows an area of irregular tessellations of the cuticle in two zones; *a*, ridged or reticulated zone on the lower and lateral surfaces; *b*, a longitudinal zone on the dorsal side of the tube.  $\times 60$ .
- Fig. 3. A section through the ridged zone; the epithelium is thrown into folds, the rounded summits are covered by the thick surface cuticle in ridge-like thickenings giving the surface a pebbled appearance as shown at *a*, figure 2.  $\times 183$ .
- Fig. 4. In this figure the ridges are in cross section as they appear on the dorsal side of the mouth tube where the surface shows irregular lines as seen in *b*, in figure 2.  $\times 36$ .
- Fig. 5. Section through the dorsal wall of the stomach; two muscular layers raised in ridges, the epithelium with its strong cuticular layer follows these ridges in outline; the cuticle becoming modified into rod-like filaments.  $\times 215$ .
- Fig. 6. Rodlets from the pyloric end of the stomach. The longitudinal muscular layer is reduced, circular layer is wide, ridges are absent but the cuticular layer becomes differentiated into rodlets, one for each cell.  $\times 215$ .
- Fig. 7. Longitudinal section through the hinder mantle margin.  $\times 215$ .
- Fig. 8. Section through the shell margin, showing high columnar epithelium.  $\times 225$ .
- Fig. 9. Epithelium of upper lip shows cilia above columnar epithelium.  $\times 258$ .
- Fig. 10. Salivary gland *in toto* as seen in figure 1, below the central nervous system.  $\times 15$ .
- Fig. 11. Lobule from salivary gland with its duct; nuclei dark and granular.  $\times 260$ .
- Fig. 12. Gland cells from the mantle; lumen of duct with large secreting cells shown in longitudinal section.  $\times 265$ .
- Fig. 13. Cross section of gland duct showing large secretion cells.  $\times 265$ .



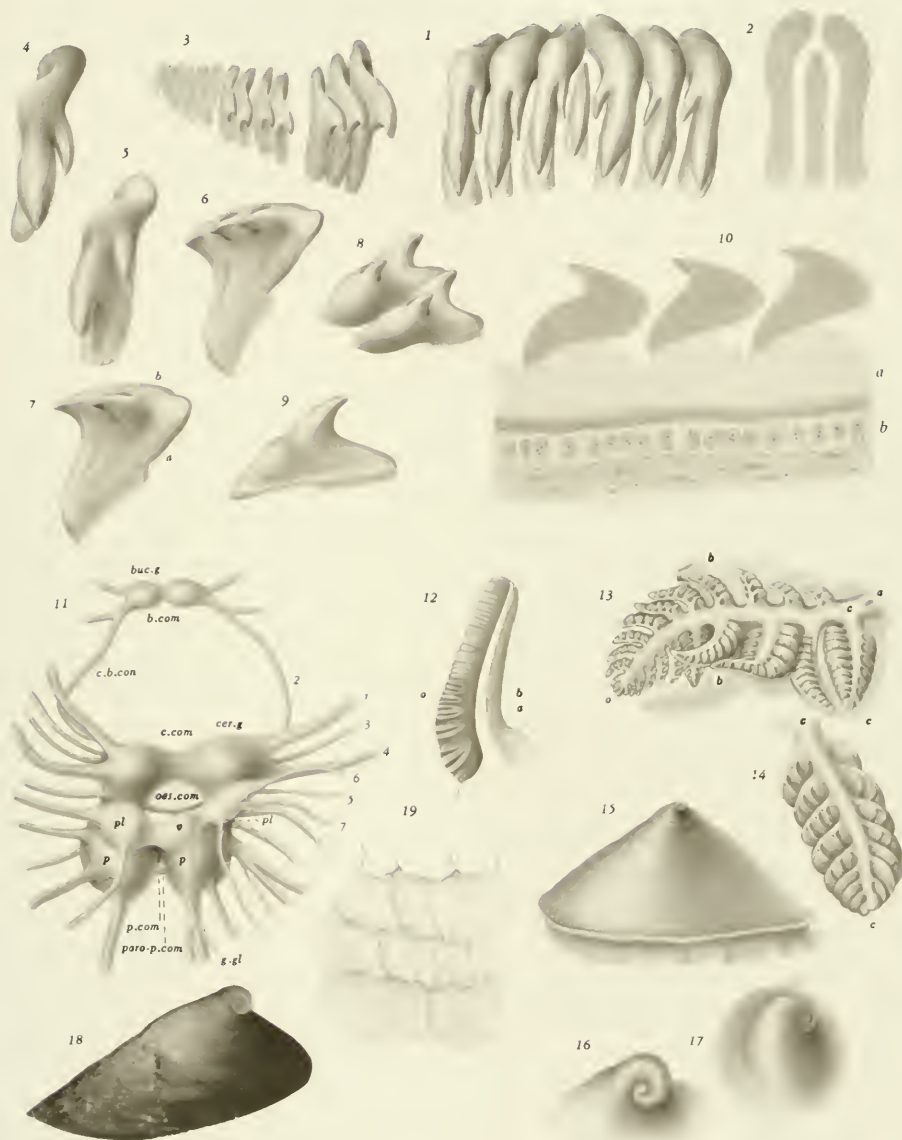


## PLATE 12

Figs. 1-19. *Tylodina fungina* Gabb

(Pages 56-68)

- Fig. 1. Fifty-third row of radula, younger section; median tooth and three laterals, viewed obliquely from above.  $\times 650$ .
- Fig. 2. Ventral side of median tooth and one lateral, 13th row.  $\times 650$ .
- Fig. 3. Outermost laterals from a young row, outer faces.  $\times 650$ .
- Fig. 4. Oblique view of tenth lateral, dorsal and inner faces, the thickened bulge at the top of large cusp is shown.  $\times 650$ .
- Fig. 5. Inner face of lateral in profile, seen from above.  $\times 650$ .
- Fig. 6. Lateral from the first row, inner face, cusp and two denticles in profile.  $\times 530$ .
- Fig. 7. Lateral from the second row with one denticle; imprint of basement cuticular layer. Dimensions, *a*, base length .044 mm.; *b*, height from point of cusp to anterior end of base .0137 mm.  $\times 530$ .
- Fig. 8. Inner face of two laterals from right side of radula.  $\times 530$ .
- Fig. 9. Profile of one lateral near the center of the radula, outer face.  $\times 530$ .
- Fig. 10. Drawing of a section through three teeth beneath the sheath; *a*, homogeneous basement layer; *b*, epithelial cells producing the cuticle above.  $\times 386$ .
- Fig. 11. Central nervous system in dorsal view; the cerebral commissure is short and broad; the oesophageal commissure is slender and long, passing just above the pleural complex. Pedal ganglia connected by a very short commissure, parapedal just below, very slender. Two pleural and one visceral ganglion are merged as if fused. Nerves are indicated on the right side only, the left being symmetrical. Buccal ganglia joined by long connectives.  $\times 17.25$ .
- Fig. 12. Detail of the rhinophore; *a*, cut edge lengthwise through the center; *b*, curved inner surface; *c*, ridges low at the top, increasing toward the base.  $\times 4.5$ .
- Fig. 13. Figure of gill, camera-lucida drawing from alcoholic specimen; dimensions, *a* to *a*, full length 10 mm.; *b* to *b*, wide over all 5 mm.; *c* to *c*, length of one large division 3 mm.  $\times 5$ .
- Fig. 14. Individual plume showing detail of platelets.  $\times 10$ .
- Fig. 15. Figure of entire shell showing the uncalcified narrow fringed band or veil extending below, 1 to 2 mm. in width; periostracum not represented.  $\times 3$ .
- Fig. 16. Side view of embryonic shell. Alcoholic specimen.  $\times 5$ .
- Fig. 17. Oblique view of embryonic shell. Same specimen.  $\times 6$ .
- Fig. 18. Photograph of the embryonic shell and periostracum.  $\times 4$ .
- Fig. 19. Free-hand drawing greatly enlarged, giving detail of the periostracum which shows the hatched overlapping of the layers of chitin in irregular rows.



## PLATE 13

Figs. 1-13. *Berthella sideralis* (Lovén)

(Pages 69-70)

Figs. 1, 2, and 3 are copied from Bergh, 1898. Malac. Untersuch., vol. 4, nos. 1-3, pl. 10, figs. 1, 2, 7 and 4.

- Fig. 1. Shell of *Berthella sideralis*; *a*, dorsal; *b*, ventral.  $\times 4$ .  
Fig. 2. Detail of mandibular cusps.  $\times 750$ .  
Fig. 3. Group of seven spicules from the integument.  $\times 100$ .

Figs. 4, 5, 6, 7, 9 are from Bergh, 1898. Malac. Untersuch., vol. 4, nos. 1-3, pl. 10, figs. 5, 6, 9, 10, 11.

- Fig. 4. Mandibular elements, in outline.  $\times 350$ .  
Fig. 5. Single element of mandible, side view.  $\times 350$ .  
Fig. 6. Two innermost teeth of the radula.  $\times 350$ .  
Fig. 7. Five outermost teeth.  $\times 350$ .  
Fig. 8. Four teeth. From Bergh, 1898. Malac. Untersuch., vol. 4, nos. 1-3, pl. 9, fig. 53.  $\times 350$ .  
Fig. 9. Profile of large tooth.  $\times 750$ .

Figs. 10, 11, 12, 13 are tracings from Odhner, 1939, *Berthella sideralis*, p. 21.

- Fig. 10. Mandibular element.  $\times 240$ .  
Fig. 11. Radula, two innermost teeth.  $\times 240$ .  
Fig. 12. Median tooth from half row.  $\times 240$ .  
Fig. 13. Outermost tooth of the radula.  $\times 240$ .

Figs. 14-24. *Berthellina engeli* Gardiner

(Pages 70-75)

- Fig. 14. Shell, *Pleurobranchus plumula* Bergh, ventral view; tracing from Bergh, 1894. Bull. Mus. Comp. Zool., vol. 25, pl. 9, fig. 12.  $\times 14$ .  
Fig. 15. Outline of mandible.  $\times 7$ .  
Fig. 16. Mandibular element, left side, showing lateral process and layers of chitin.  $\times 170$ .  
Fig. 17. Mandibular element, right side.  $\times 170$ .  
Fig. 18. Three mandibular elements from above.  $\times 170$ .  
Fig. 19. Three mandibular elements, seen from below.  $\times 170$ .  
Fig. 20. A single element seen obliquely from above.  $\times 170$ .  
Fig. 21. Typical lateral tooth from the radula, seen in profile.  $\times 250$ .  
Fig. 22. Innermost lateral.  $\times 250$ .  
Fig. 23. Tip of lateral, seen obliquely, showing detail of the denticles.  $\times 250$ .  
Fig. 24. Lateral, showing denticle detail under high magnification.  $\times 425$ .

Figs. 25-34. *Pleurobranchus californicus denticulatus* MacFarland, new subspecies

(Pages 84-89)

- Fig. 25. Mandible outline.  $\times 12$ .  
Fig. 26. One mandibular element, dorsal view, showing denticles.  $\times 350$ .





- Fig. 27. Single element, seen from below.  $\times 350$ .  
Fig. 28. Lateral view showing the knob-like process and denticles on the right of the cusp.  $\times 350$ .  
Fig. 29. Four outermost teeth of the radula, seen from above.  $\times 650$ .  
Fig. 30. Tooth from the middle of the eighth row, wide, flattened base.  $\times 650$ .  
Fig. 31. Second lateral tooth.  $\times 650$ .  
Fig. 32. Innermost lateral.  $\times 650$ .  
Fig. 33. Six outermost laterals in profile, base seen obliquely.  $\times 650$ .  
Fig. 34. Three mandibular elements from above.  $\times 350$ .

Figs. 35-37. *Pleurobranchus californicus* Dall  
(Pages 82-84)

- Figs. 35,36. Tracings of two groups of teeth from Bergh, 1904. Wiss. Res., vol. 9. Malac. Untersuch., vol. 6, pl. 1, figs. 25, 26.  $\times 350$ .  
Fig. 37. Tracing of mandibular elements. Bergh, reference same, fig. 24.  $\times 350$ .

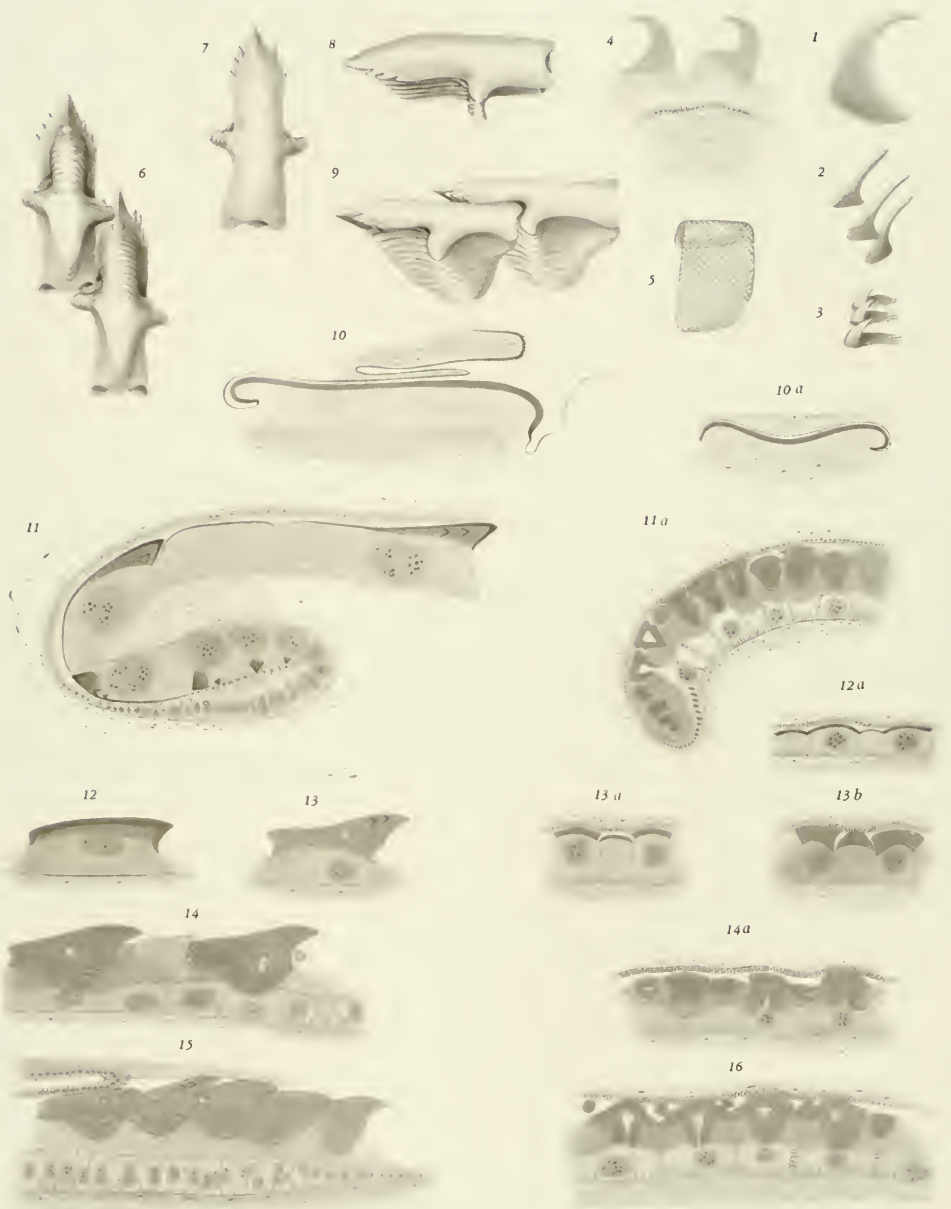


## PLATE 14

Figs. 1-16. *Pleurobranchus digueti* Rochebrune

(Pages 75-82)

- Fig. 1. Profile of large tooth from the middle of a row.  $\times 126$ .  
Fig. 2. Outermost three teeth.  $\times 126$ .  
Fig. 3. Three innermost teeth from the left side of the radula.  $\times 126$ .  
Fig. 4. Drawing of longitudinal section through two teeth, showing the basement layer, epithelium, and connective tissue below.  $\times 126$ .  
Fig. 5. Outline of one mandible.  $\times 3.4$ .  
Fig. 6. Ventral view of two mandibular platelets showing the relation of the lateral processes to each other.  $\times 126$ .  
Fig. 7. Platelet, dorsal surface.  $\times 126$ .  
Fig. 8. Platelet seen in an oblique view.  $\times 126$ .  
Fig. 9. Two platelets from the older part of the mandible, seen in profile, showing cusp and base.  $\times 126$ .  
Fig. 10. Mandible as seen in longitudinal section which shows its relation to the radula above and the deep pocket below.  $\times 10$ .  
Fig. 10a. Cross section through the posterior part of the mandible.  $\times 10$ .  
Fig. 11. Longitudinal section through the sulcus, showing the development of the mandibular elements in all stages.  $\times 180$ .  
Fig. 11a. Cross section near the same place showing the relation of the elements.  $\times 180$ .  
Fig. 12. Longitudinal section of a single cell with a thin layer of cuticle.  $\times 110$ .  
Fig. 12a. Cross section through two cells, same stage in development.  $\times 110$ .  
Fig. 13. Longitudinal section showing the cuticular cap developing a cusp with two denticles.  $\times 110$ .  
Fig. 13a. Cross section through two cells developing chitin.  $\times 110$ .  
Fig. 13b. Cross section showing chitin well developed as in longitudinal section, figure 13.  $\times 110$ .  
Fig. 14. Longitudinal section which shows the increase in the basal layers of the elements.  $\times 110$ .  
Fig. 14a. Cross section of the elements in the same stage of development.  $\times 110$ .  
Fig. 15. Longitudinal section shows the decrease in the size of the elements as the older portion is reached; the basal epithelium becomes like the general epithelium of the mouth; each platelet is embedded in a transparent cuticular layer which reaches its greatest thickness at the end of the mandible.  $\times 110$ .  
Fig. 16. Cross section in the region of figure 15. Basal clefts show in the cells; spaces in the center of the elements with no chitin; a distinct basal fibrillation is seen, the nuclei are large and vascular, crowded with chromatin granules.  $\times 110$ .



## PLATE 15

Figs. 1-15. *Pleurobranchus strongi* MacFarland, new species

(Pages 89-93)

- Fig. 1. Dorsal view of shell with rim indicated; measurements of shell with rim 7.5 mm.  $\times 4$  mm.; specimen from White's Point, San Pedro. Collected by A. M. Strong.  $\times 10$ .
- Fig. 2. An enlargement of the spire, left margin posterior end, made on the ventral side, showing the nucleus from below with the growth lines clearly drawn.  $\times 20$ .
- Fig. 3. Dorsal view of spire under higher magnification. The innermost portion of the spire is slightly arched, the outer whorl becoming much flattened, thinning away on the edge.  $\times 32$ .
- Fig. 4. Mandibles in outline, upper side.  $\times 14$ .
- Fig. 5. Mandibular elements in position, seen from above. The denticles of the cusps and lateral processes shown fitted together.  $\times 140$ .
- Fig. 6. Side view of two mandibular elements showing the lateral processes.  $\times 140$ .
- Fig. 7. A single element from the mandible, dorsal surface.  $\times 386$ .
- Fig. 8. Three teeth from the inner margin, 48th from the outer end.  $\times 650$ .
- Fig. 9. Teeth from the outermost margin of the radula, inner face.  $\times 880$ .
- Fig. 10. Inner face of two teeth from the middle of the row.  $\times 650$ .
- Fig. 11. Outer face of two teeth from the 13th row.  $\times 650$ .
- Fig. 12. *Pleurobranchus strongi*, drawing made of a live specimen taken from Point Pinos, Monterey Bay. Here, with carbon, an attempt is made to represent the texture of the dorsum which is finely papillose; scattered larger papillae are near the margin, the close network of vermicular markings seem characteristic of the species, all studied alive.  $\times 3$ .
- Fig. 13. Gill plume 7.3 mm. long, free portion about half its length; rachis smooth, no tubercles, 16 to 20 bipinnate pinnules, thin plates arising from a central rib.  $\times 4.4$ .
- Fig. 14. Dorsal view of the rhinophores showing the inrolled margins and the union at the base below the deeply notched anterior margin of the dorsum.  $\times 6$ .
- Fig. 15. Head with one rhinophore shown in profile. The inner roll, the anterior marginal line extending laterally into a free lobe, the grooved lateral margins of the veil are all clearly shown.  $\times 7.5$ .

Figs. 16-28. *Pleurobranchaea californica* MacFarland, new species

(Pages 94-101)

Radula. All  $\times 38$  magnification.

- Fig. 16. Dorsal view of central tooth, three laterals in place.
- Fig. 17. Ventral view of same central tooth and the three laterals on either side; bases and hook-like facet shown.
- Fig. 18. Large lateral tipped ventrally, showing the throat and the base which is implanted in the general basal cuticle at an angle of about 45 degrees.
- Fig. 19. Profile view drawing of central tooth.
- Fig. 20. Three lateral teeth in profile, 99, 100, 101.
- Fig. 21. First eight laterals from the end of the row.
- Fig. 22. Two typical laterals from the inner half of the row, base compressed and elongated; inner face.
- Fig. 23. Tooth from a young specimen, inner face seen at a ventral angle, thin wing extending below on outer face, the ventral edge is continued downward into the dorsal surface of the rounded facet at the hinder end of the base; small lateral denticle clearly seen in the last two preceding figures. Dimensions of lateral from young specimen: length, tip of base to tip of cusp .270 mm.; length of base .144 mm.; denticle .039 mm.; length of cusp .132 mm.
- Fig. 24. Outer face of two adult teeth, base compressed and elongated; thin wing on margin extending beyond the base line.
- Fig. 25. Base of two laterals, the posterior part narrows abruptly terminating in a hollowed, rounded, hook-like facet with thickened margins and concave center.
- Fig. 26. Section across a large tooth at the upper end of the throat.
- Fig. 27. Cross section showing left side, inner face, above the small denticle.
- Fig. 28. Right side, outer face, cross section above the crescentic tip at the end of the base.



## PLATE 16

Figs. 1-8. *Tylodina fungina* Gabb

(Pages 56-68)

- Fig. 1. Reproductive system. Represented in a semidiagrammatic manner. The figure shows the ootestis acini uniting into the common hermaphroditic duct which swells into the hermaphroditic ampulla; upon narrowing, this enters the thin-walled ciliated chamber in the adnexed genital mass. Close to this entrance, the common genital duct emerges, which becomes embedded in the musculature of the right body wall reaching the external genital opening below the right anterior tentacle. (Pl. 5, fig. 7.) The common genital duct is traversed by a strong longitudinal ridge dividing it incompletely into channels, *a*; common genital duct, *g. d.*; *b* (pl. 16, fig. 7), a muscular duct arising close to the external opening, passing backward, terminating as a blind dilated sac, the spermatheca or receptaculum seminis, its duct being the oviduct.  $\times 10$ .

Figs. 2-5. Camera-lucida drawings of the reproductive parts, made from dissections and serial sections. Each  $\times 40$ .

- Fig. 2. Cross section, just back of the external opening, shows the genital duct, *a*, at its juncture with the duct of the spermatheca at *b*.
- Fig. 3. Cross section of the genital and spermatheca ducts, *a* and *b*, showing the muscular wall of *b*, and the proximity of the genital duct, *a*.
- Fig. 4. Figure shows the two ducts in a similar position as in figure 3.
- Fig. 5. The anterior end of the spermatheca in cross section; the spermatozoa are attached to its walls; an arm of the genital duct is in view.
- Fig. 6. Detail of the wall of the spermatheca with its high columnar epithelium with large nuclei, the distal ends are vague. The spiral spermatozoa are embedded in its walls.  $\times 372$ .
- Fig. 7. The external contour of the verge is shown; non-invaginable with no sign of a preputial sheath. The integument is cut away to show the ducts, *a* and *b*. It is not the usual tectibranch condition.  $\times 10$ .
- Fig. 8. The figure shows the narrow groove passing inward on the upper concave surface of the verge. Into this groove the genital ducts open. Relations are not clear and more material is needed.  $\times 7.5$ .

Fig. 9. *Berthellina engeli* Gardiner

(Pages 70-75)

- Fig. 9. Drawing of a dissection of the reproductive system.  $\times 12$ .

Figs. 10, 11. *Pleurobranchus digueti* Rochebrune

(Pages 75-82)

- Fig. 10. Dorsal view of the reproductive organs; figure semidiagrammatic. About  $\times 5$ .
- Fig. 11. Ventral view of the verge which has a wing on one side.  $\times 5$ .

Fig. 12. *Pleurobranchus californicus denticulatus* MacFarland, new subspecies

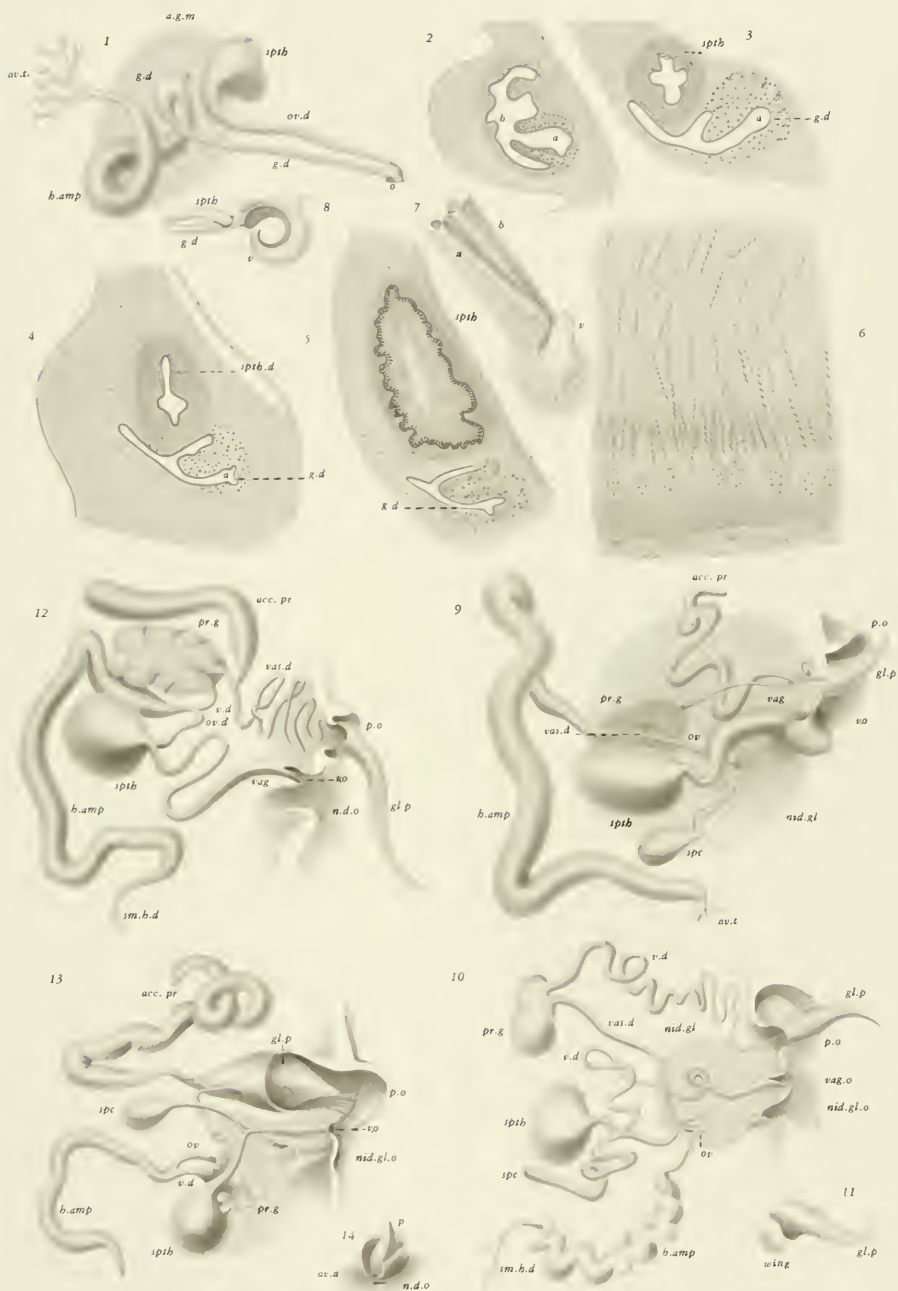
(Pages 84-89)

- Fig. 12. A composite camera-lucida drawing of the reproductive system made from dissections of the parts, together with the use of serial sections.  $\times 14$ .

Figs. 13, 14. *Pleurobranchus strongi* MacFarland, new species

(Pages 89-93)

- Fig. 13. Drawing of the reproductive system from dissections.  $\times 5$ .
- Fig. 14. Detail showing the relative positions of the three external openings; glans, vaginal, nidamental or accessory glands.  $\times 5$ .



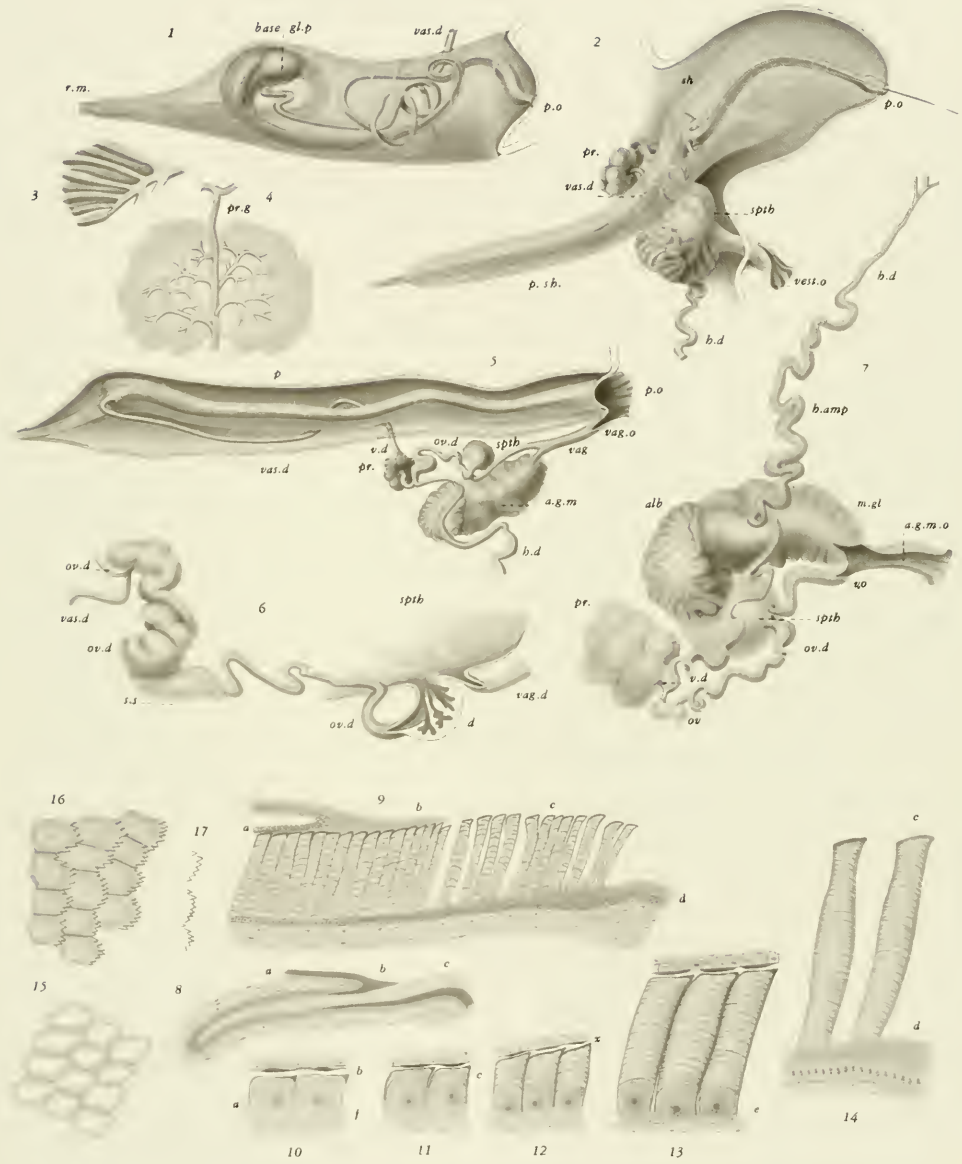


## PLATE 17

Figs. 1-17. **Pleurobranchaea californica** MacFarland, new species

(Pages 94-101)

- Fig. 1. Ventral view, adult specimen, of partly everted penis; vas deferens penetrates the outer sheath, describes a number of loops, and enters the expanded base of the penis; retractor muscle enters sheath, loops and becomes attached to the base.  $\times 3.7$ .
- Fig. 2. Ventral view of large specimen shows the glans penis in an almost completely everted condition; hermaphroditic duct enters the adnexed genital complex, vas deferens leaves the prostate gland, pierces the sheath near the base of the penis which it enters; distally the preputium is somewhat dilated; through it the glans emerges, passing the male aperture in the center of a large papilla.  $\times 1.8$ .
- Fig. 3. A section of the lobes of the prostate gland, the surface showing the rounded tips of the deep tubules radially arranged.  $\times 7$ .
- Fig. 4. Ducts of the tubules of the prostate gland which open into the vas deferens as it passes through the gland.  $\times 7$ .
- Fig. 5. Dorsal surface of a small immature specimen, penis in a completely retracted condition at full length; vas deferens enters its sheath, connects with the base; the oviduct enters the spermatheca, emerging as the vaginal duct passing into the vagina which reaches the genital cloaca, accompanied by the duct from the genital mass.  $\times 10$ .
- Fig. 6. Figure showing the cavity of the spermatheca. Oviduct presents a thick-walled, convoluted, saccular segment; becomes a narrow duct which dilates into a reniform enlargement at the point of its connection with the spermatheca; the thickened wall is thrown into a number of diverticula; the vaginal duct emerges adjacent to the oviduct entrance.  $\times 5$ .
- Fig. 7. A dorsal view shows the hermaphroditic duct and ampulla which enters the adnexed genital complex passing above the large spermatheca, dividing into the vas deferens and oviduct; the vas deferens enters the prostate gland, the tubules of which show in surface view; the oviduct dilates upon its entrance into the spermatheca, emerges as the vaginal duct, passing into the vagina which has its external opening at the side of the short broad duct of the accessory glands.  $\times 3$ .
- Fig. 8. Longitudinal celloidin section of mandible *in situ*, showing all stages of development of the rodlets from the sulcus to the outer end.  $\times 12$ .
- Fig. 9. General view of rodlets: *a*, low cuboidal epithelium of the mouth above rests upon a homogeneous basement membrane; *b*, marks a distinct cuticle on the free surface which shows lenticular thickenings opposite the distal ends of the mandible rodlets formed upon the cells of the opposite wall (figs. 10-13 at *x*, fig. 12); *c*, marks the fully developed rodlets with a homogeneous cuticle; *d*, developed below.  $\times 50$ .
- Fig. 10. Two cells near the sulcus; *a*, early stage of rhabdoplast; *b*, first indication of top plate with pointed denticle on the outer margin; *f*, basal zone.  $\times 120$ .
- Fig. 11. Two rhabdoplasts showing delicate layer of chitin on free surface; *c*, first appearance of cuticular layers below the denticular ridge.  $\times 120$ .
- Fig. 12. Three rodlets showing thickening of cuticle of outer cells which fit depressions of the rodlets opposite.  $\times 120$ .
- Fig. 13. Group of three rodlets; *e*, rhabdoplast nucleus shows a large nucleolus and small chromatin granules, granular cytoplasm.  $\times 120$ .
- Fig. 14. Fully developed rodlets; rhabdoplasts have disappeared, replaced by slender columnar cells which form a homogeneous cuticular basal layer, *d*, upon which they rest; *c*, distal ends somewhat irregular on the worn edge.  $\times 120$ .
- Fig. 15. Section through rodlets, anterior end of mandible; elongated hexagons.  $\times 180$ .
- Fig. 16. Surface view of mandible plate showing small polygonal areas, denticles on outer margin.  $\times 180$ .
- Fig. 17. Denticles as seen separated from rodlet.  $\times 180$ .



## PLATE 18

Figs. 1-4. **Polycera atra** MacFarland  
(Pages 115-118)

- Fig. 1. Drawing made from above, shows a specimen from Monterey Bay in which the black color usually predominates.  $\times 4$ .  
Fig. 2. Made from a photograph of the living animal, giving a view of head, foot, and gill.  $\times 3$ .  
Fig. 3. Same specimen as above in which the dorsum is uppermost, the gill fully expanded, showing the form of the individual plumes.  $\times 3$ .  
Fig. 4. Two details, *a*, outside; *b*, inside of gill elements. Northern and southern forms have these with coloring and the placing identical.  $\times 10$ .

Figs. 5-8. **Aegires albopunctatus** MacFarland  
(Pages 101-103)

- Fig. 5. Drawing made of dorsum, directly from above.  $\times 7$ .  
Fig. 6. Left side of specimen, showing gill.  $\times 7$ .  
Fig. 7. Enlargement of rhinophores of living specimen in 5, 6; *a*, left and *b*, right rhinophore seen from above and within.  $\times 18$ .  
Fig. 8. Camera-lucida drawing, enlarged rhinophore of alcoholic specimen: *a*, left from above, within; *b*, right rhinophore seen obliquely from within.  $\times 10$ .



## PLATE 19

Figs. 1, 2. **Triopha grandis** MacFarland  
(Pages 112-115)

- Fig. 1. Specimen from kelp beds of inner Monterey Bay. Lateral view, pale blue spots cover the general orange color of the entire body. A range of orange, from the pale shades to the deepest red-orange was found in the collection from the same kelp.  $\times 1$ .  
Fig. 2. Same specimen, seen directly from above; gill fully spread.  $\times 1$ .

Figs. 3, 4. **Triopha carpenteri** (Stearns)  
(Pages 106-109)

- Fig. 3. Right side of fully extended specimen is shown. Painted by Anna B. Nash.  $\times 2$ . Reproduced from MacFarland, 1906. Bull. U. S. Bureau of Fisheries, vol. 25, pl. 27, fig. 17.  
Fig. 4. Same specimen seen obliquely from above. Painted by Anna B. Nash.  $\times 2$ . *Op. cit.*, pl. 27, fig. 16.

Figs. 5, 6. **Triopha maculata** MacFarland  
(Pages 109-112)

- Fig. 5. The animal is resting on a branch of alga, turned, showing the dorsum left, and right sides with a favorable view of the sloping head. Painted by Anna B. Nash.  $\times 2$ . Painting reproduced from MacFarland, 1906. Bull. U. S. Bureau Fisheries, vol. 25, pl. 28, fig. 18.  
Fig. 6. Enlarged detail from the dorsum, made to show the polygonal eminences bounded by an orange line, centered by a blue spot.  $\times 3$ .





## PLATE 20

Figs. 1-3. **Trapania velox** (Cockerell)

(Pages 127-129)

- Fig. 1. Drawing made from the living animal; two specimens were studied. Lateral view, the unusual profile of the dorsum is shown, also the finger-like processes at the base of the rhinophores and gill. The rich brown coloring seems to have depth and texture.  $\times 6$ .
- Fig. 2. Study directly from above, the same specimen; this, together with the lateral view, shows all parts clearly.  $\times 6$ .
- Fig. 3. Drawing of the ventral head region. The anterior margin of the foot bears a series of small papillae, directed forward.  $\times 6$ .

Fig. 4. **Laila cockerelli** MacFarland

(Pages 104-106)

- Fig. 4. Figure reproduced from MacFarland, 1906. Bull. U. S. Bureau Fisheries, vol. 25, pl. 27, fig. 15. Painted by Anna B. Nash.  $\times 6.5$ .

Figs. 5, 6. **Acanthodoris brunnea** MacFarland

(Pages 118-120)

- Fig. 5. Animal an average length of 20 mm., having large rhinophores and very large tubercles thickly set on the dorsum. Figure reproduced from MacFarland, 1906. Bull. U. S. Bureau Fisheries, vol. 25, pl. 29, fig. 20. Painted by Anna B. Nash.  $\times 6$ .
- Fig. 6. Detail of the dorsal papillae. From MacFarland, 1906. *Op. cit.*, pl. 29, fig. 21. Painted by Anna B. Nash.  $\times 20$ .



## PLATE 21

Fig. 1. **Ancula pacifica** MacFarland

(Pages 123-124)

- Fig. 1. Figure reproduced from painting by Anna B. Nash from life, MacFarland, 1906. Bull. U.S. Bureau of Fisheries, vol. 25, pl. 30, fig. 23. Oblique view from above, giving a top view of the head, lateral, of the three divisions of the gill, pinnate leaves, alternating long and short, arranged in a semicircle. Extra branchial appendages bound these on either side. Note the large rhinophores with two processes at the base. It is a most graceful animal about 15 mm. in length as an average specimen.  $\times 6$ .

Figs. 2. 3. **Hopkinsia rosacea** MacFarland

(Pages 125-126)

- Fig. 2. A most striking nudibranch in the tide pool and usually abundant in the summer months. Figure reproduced from MacFarland, 1906. *Op. cit.*, pl. 31, fig. 24. Painted from life by Anna B. Nash. Dorsal view.  $\times 5$ .
- Fig. 3. Ventral view of same specimen painted from life by Anna B. Nash. Note anterior margin and mouth parts. *Op. cit.*, pl. 31, fig. 25.  $\times 5$ .



## PLATE 22

Figs. 1-5. *Glossodoris macfarlandi* (Cockerell)

(Pages 153-157)

- Fig. 1. View from above of a 32 mm. specimen; two living specimens were studied and accurate measurements taken. The coloring is most lovely and the gradations of tone unusual. The general ground color is a deep violet, rose madder, and permanent blue, paler in the mid-dorsal and foot areas. Cadmium orange edges the entire mantle, bounding a sub-marginal white band which merges with the violet of the body.  $\times 2.6$ .
- Fig. 2. Oblique view from above, the gill seen to advantage, also the top and anterior of the rhinophores.  $\times 2.6$ .
- Fig. 3. The animal floats with foot uppermost, showing the mouth and anterior foot margin, a white band encircles the mantle below with no yellow marginal line.  $\times 2.6$ .
- Fig. 4. Detail of the rhinophore shows the anterior surface obliquely, the plates joining in a depressed ridge. The plates are exceedingly dark, crimson lake and permanent blue, making the rhinophores the most striking feature of the dorsum.  $\times 8.5$ .
- Fig. 5. The gill plumes repeat the rhinophore colors, the dark of the lamellae extending down but one-third of the stalk, becoming pale below.  $\times 8$ .

Figs. 6-8. *Corambe pacifica* MacFarland and O'Donoghue

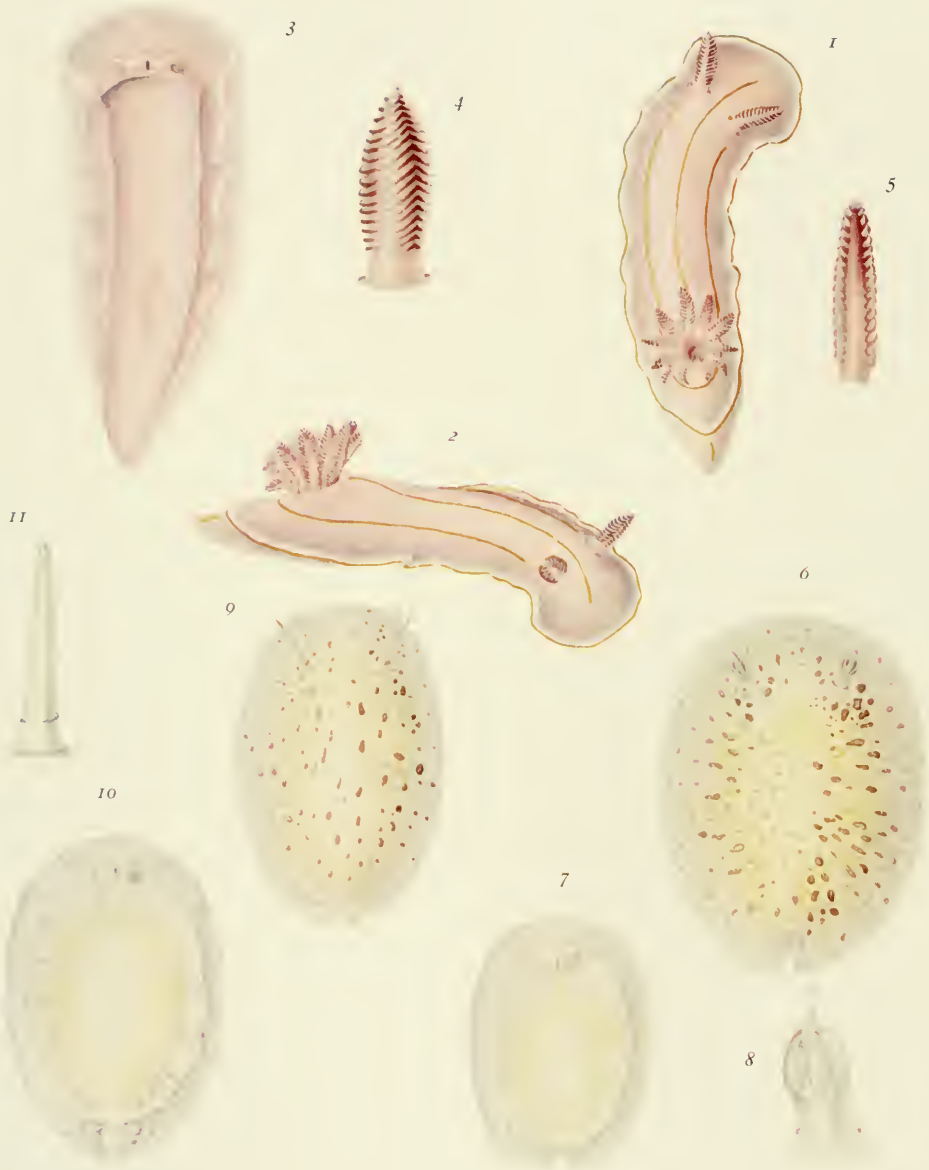
(Pages 130-132)

- Fig. 6. Specimen painted measured 13 mm. long by 10 mm. in width. The posterior notch, pinnate gill plumes, lobed liver outline, all characteristic of the genus, are represented.  $\times 4.7$ .
- Fig. 7. Ventral view is made with lower magnification. Mouth, edge of foot, relation of the gill to the dorsum and notch, pale yellow of liver lobes clearly shown.  $\times 3.5$ .
- Fig. 8. Enlarged drawing of the rhinophore to show the expanded cylindrical stalk with its outer envelope, the pair of inner laminae and the third vertical unpaired one on the median face.  $\times 17$ .

Figs. 9-11. *Corambella bolini* MacFarland, new species

(Pages 134-139)

- Fig. 9. The specimen painted measured 11 mm. long by 7.5 mm. wide and represents the new species *Corambella bolini*. The smooth tapering rhinophores, the continuous oval outline of the dorsum, at once separate this from the genus *Corambe*.  $\times 5$ .
- Fig. 10. In this the ventral parts of this species are figured. The branchiae on either side of the median anal opening arise in two pairs, two to four on either side. The largest innermost gill shows a flattened stalk bearing three to four small flattened lamellae, the outer gills have fewer or may consist of the stalk alone. Clearly shown is a crescentic series of alveolar glands above the gill stalks.  $\times 5$ .
- Fig. 11. Figure of an enlarged rhinophore which is smooth, tapering to a blunt tip, one-third the body length; carried almost erect, diverging outward. A close fitting sheath, with smooth margin, surrounds the base.  $\times 16$ .





## PLATE 23

Fig. 1. ***Cadlina flavomaculata*** MacFarland  
(Pages 144-147)

- Fig. 1. *Cadlina flavomaculata* MacFarland, dorsal view. Painted by Anna B. Nash.  $\times 10$ . Reproduced from MacFarland, 1906. Bull. U. S. Bureau Fisheries, vol. 25, pl. 25, fig. 9.

Figs. 2-4. ***Cadlina luteomarginata*** MacFarland, new name  
(Pages 140-144)

- Fig. 2. *Cadlina luteomarginata* MacFarland, new name, ventral view. Painted by Anna B. Nash.  $\times 3$ . *Op. cit.*, pl. 25, fig. 10.  
Fig. 3. *Cadlina luteomarginata*, dorsal view. Painted by Anna B. Nash.  $\times 3$ . *Op. cit.*, pl. 25, fig. 11.  
Fig. 4. Detail of dorsum, figure 3, highly magnified. Painted by Anna B. Nash. *Op. cit.*, pl. 25, fig. 12.

1



2



4



3



## PLATE 24

**Figs. 1-3. *Chromodoris californiensis* Bergh**  
(Pages 157-162)

- Fig. 1. Dorsal view of 60 mm. specimen. This figure shows clearly the characteristic white line which forms the mantle margin in a ridge-like lateral edge on the sides, increasing in width about the veil and merging gradually into the body color, a very bright deep blue; marine blue and carmine give the color. Posteriorly, the white of the marginal edge ceases at the gill, the dorsal tip of the mantle becoming a much darker shade, of a velvety appearance. This area bears several prominent, hemispherical, glandular elevations on its ventral surface. These features show clearly in figure 3. The yellow spots on the dorsum are a clear bright orange.  $\times 2$ .
- Fig. 2. The ventral area of the narrow foot is exposed its full length. The anterior margin bilabiate; the tips of the labial tentacles and the rhinophores protruding, of the same intense blue found on the posterior dorsum. The wide veil projects beyond the mouth parts.  $\times 2$ .
- Fig. 3. This figure gives a lateral view which, with the dorsal view, depicts clearly the gill with its twelve divisions of an intense blue, found too, on the rhinophore plates.  $\times 2$ .

**Figs. 4, 5. *Chromodoris porterae* Cockerell**  
(Pages 163-165)

- Fig. 4. View directly from above. General color permanent blue, differing markedly from the intense blue of *C. californiensis*. A pale-blue line encircles the mantle, bordered by a pure-white line. The pale blue passes lengthwise on the center of the dorsum. Encircling the dorsum is a wide-yellow band, the surface of which is mottled with orange-yellow.  $\times 5$ .
- Fig. 5. Profile of the same specimen shows the break in the orange band below the rhinophores, the productive opening, the long pointed tail.  $\times 5$ .



## PLATE 25

Figs. 1-6. *Doris* (*s. l.*), species  
(Pages 179-180)

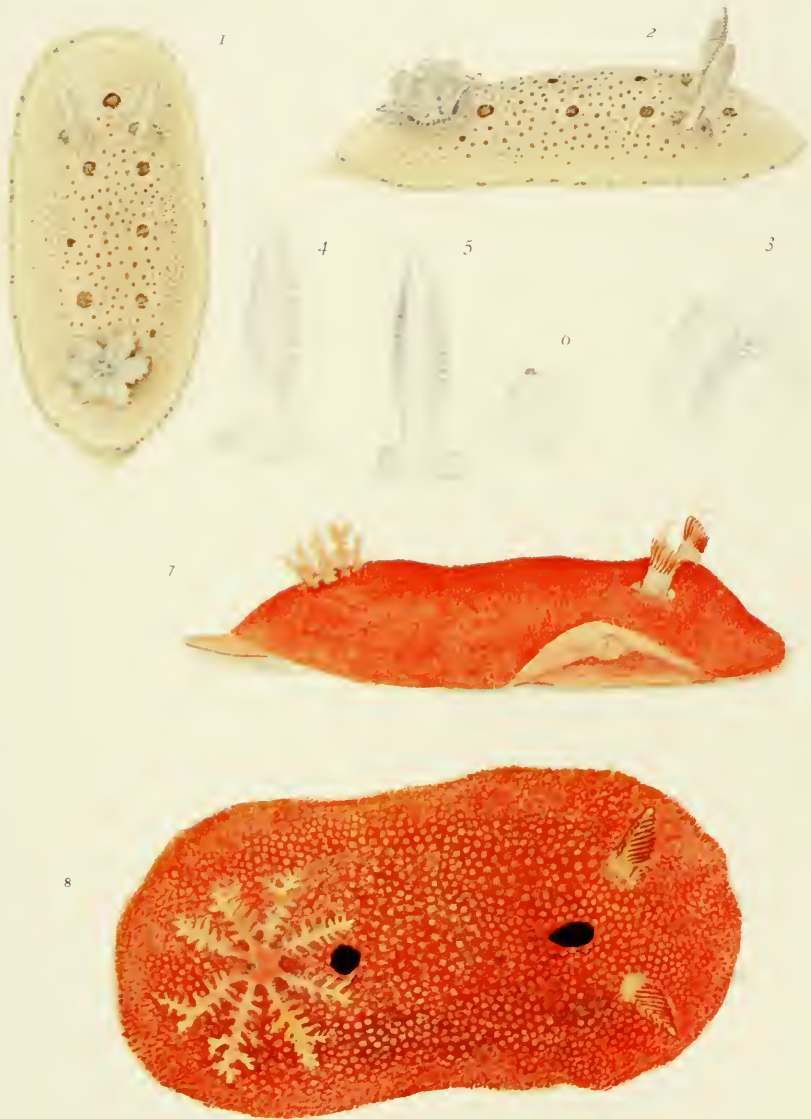
- Fig. 1. Small dorid found by the author at Arch Rock, Newport Bay. Careful measurements, drawings, and paintings were made of the living specimen; the final decision as to genus and species was not determined. The first figure pictures the dorsum which is thickly set with small papillae, each capped by a flake of pure white, giving the surface a frosted appearance. Scattered everywhere are minute dots of vandyke brown. A marginal zone of 3 mm. encircles the dorsum. In this zone the papillae are exceedingly minute, marked by the white and brown flecks; the band, thus made, is set definitely apart from the remaining surface.  $\times 3$ .
- Fig. 2. A profile view shows the long rhinophores and the delicate gill which retracts into an opening edged by large papillae. The dorsum is adorned by a double row of brown circular spots, one being found in anterior position, between the rhinophores.  $\times 3$ .
- Fig. 3. This shows the ventral head parts; anterior margin of the foot bilabiate, notched.  $\times 3$ .
- Fig. 4. Profile of the right rhinophore to show clearly the ridge centered on the posterior side.  $\times 7.5$ .
- Fig. 5. Anterior face of the rhinophore on which there is a groove into which the plates terminate.  $\times 7.5$ .
- Fig. 6. Cross section of rhinophore stalk, passing through the plates, ridge and groove, above described.  $\times 12$ .

Fig. 7. *Rostanga pulchra* MacFarland  
(Pages 165-169)

- Fig. 7. Lateral view, figure taken from MacFarland, 1906. Bull. U. S. Bureau Fisheries, vol. 25, pl. 24, fig. 8.  $\times 10.5$ . Painted by Anna B. Nash.

Fig. 8. *Aldisa sanguinea* (Cooper)  
(Pages 169-171)

- Fig. 8. Dorsal view of large specimen.  $\times 7$ . *Op. cit.*, pl. 24, fig. 7. Painted by Anna B. Nash.





## PLATE 26

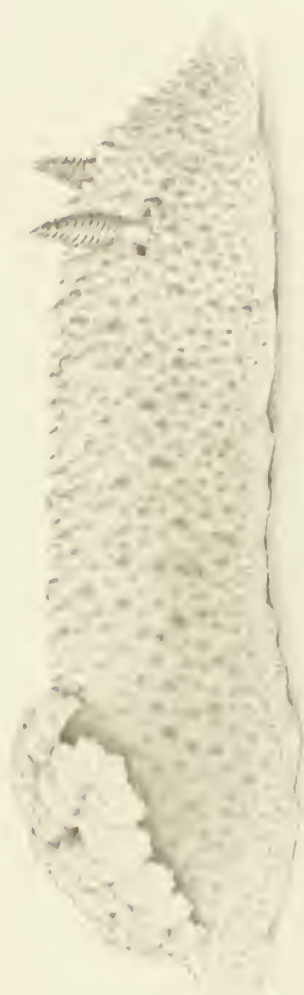
Fig. 1. *Austrodoris odhneri* MacFarland, new species  
(Pages 173-179)

Fig. 1. Lateral view, from a water color study of the living animal.  $\times 2$ .

Measurements and drawings were made from a specimen 89 mm. in length, 42 mm. in width, 20 mm. in height; collected by W. H. Spaulding at Cypress Point, Monterey Bay, 1904. The painting was done in 1925, using three specimens collected that year, one at Cypress Point and two at Point Pinos, Monterey Bay; a wanderer, from the Antarctic regions, and most striking as it is found in a crystal pool, resting on a bed of green alga.

It is pure white, with an encrusting of dead white on the dorsal tubercles; the gill is so transparent and feathery that it forms the most handsome plume of all the dorids.

It is very perplexing to attain a neutral shadow color in painting white nudibranchs, as they are observed over a background of black or white. In this instance, payne's gray was used as it more accurately accented the white; perhaps a neutral gray would be more as nature makes it.



## PLATE 27

Figs. 1-5. **Petelodoris spongicola** MacFarland, new species  
(Pages 183-187)

- Fig. 1. Lateral view, painted from a living specimen; 65 mm. long, 30 mm. wide, 23 mm. high.  $\times 1.3$ .  
Fig. 2. Dorsal view of the same specimen. Color is very similar to that of the sponge upon which it was found. This new species has very pronounced characteristics; notum thickly set with hispid papillae, dense with spicules, giving the surface a great similarity to its habitat sponge. An irregular ridge extends along the mid-dorsal line, branchiae found beneath the greatly thickened lobes extending from the dorsum; rhinophore with thick stalk, surrounded by a greatly thickened sheath with rounded margins.  $\times 1.3$ .  
Fig. 3. Detail showing the branchiae and lobes above.  $\times 3$ .  
Fig. 4. Camera-lucida drawing, from an alcoholic specimen, of the ventral parts of the head.  $\times 3$ .  
Fig. 5. Enlarged detail of the rhinophore, made from the back.  $\times 3$ .

Fig. 6. **Diaulula sandiegensis** (Cooper)  
(Pages 190-192)

- Fig. 6. Reproduced from MacFarland, *Opisthobranchiate Mollusca from Monterey Bay, California, and Vicinity, 1906*. Bull. U. S. Bureau of Fisheries, vol. 25, pl. 23, fig. 5. Dorsal view showing ringed spots, characteristic of the genus.  $\times 1.8$ . Painting by Anna B. Nash.

Fig. 7. **Discodoris heathi** MacFarland  
(Pages 192-193)

- Fig. 7. Figure reproduced from MacFarland, 1906. *Op. cit.*, pl. 23, fig. 6. A reduction was made.  $\times 2.8$ .

Fig. 8. **Archidoris montereyensis** (Cooper)  
(Pages 181-182)

- Fig. 8. Redrawn from MacFarland, 1906. *Op. cit.*, pl. 23, fig. 4.  $\times 2$ .



## PLATE 28

Figs. 1, 3. **Anisodoris nobilis** (MacFarland)  
(Pages 188-190)

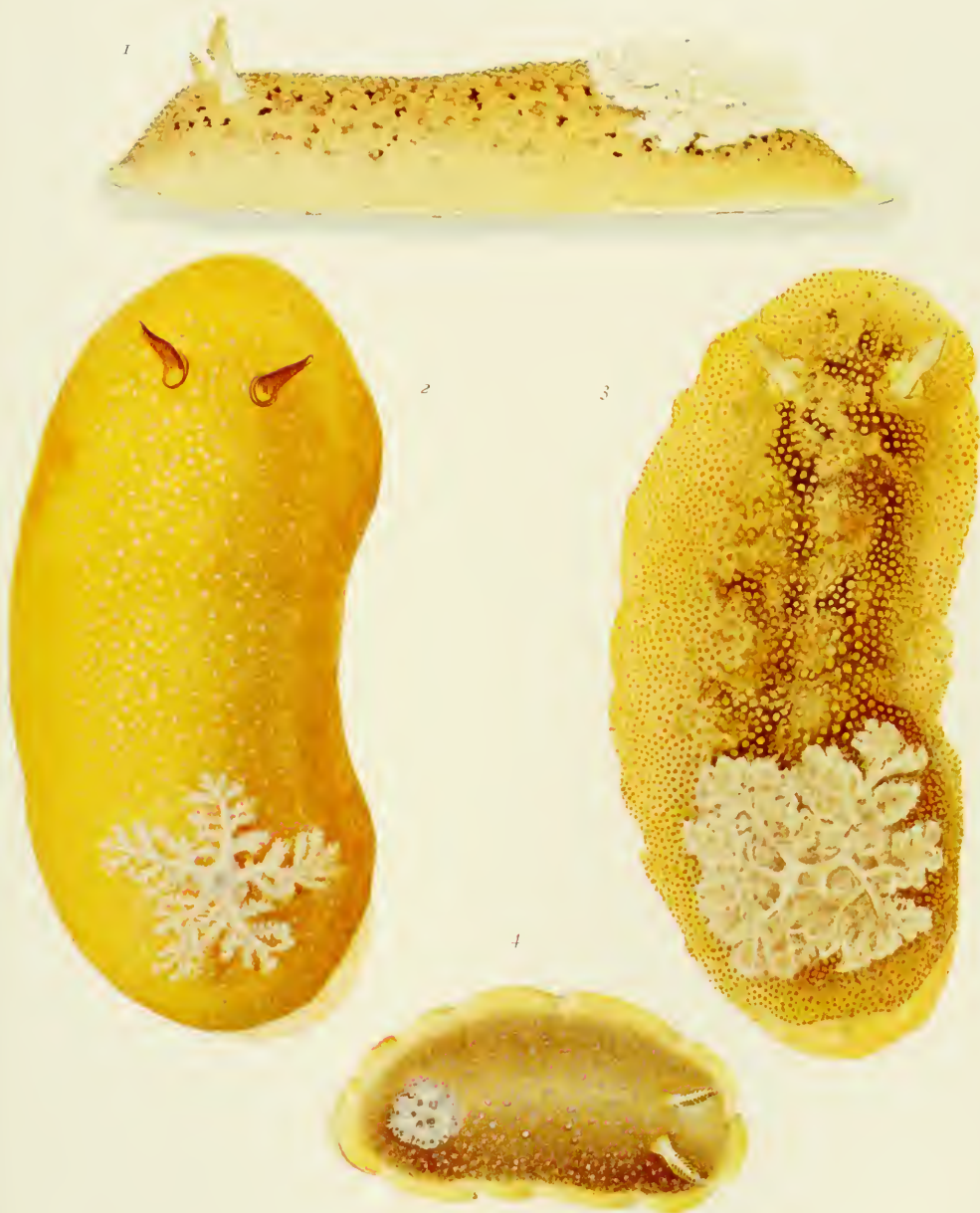
- Fig. 1. Figure from MacFarland, 1906. Bull. U. S. Bureau Fisheries, vol. 25, pl. 22, fig. 1. Painting made of living specimen. Lateral view is shown.  $\times 875$ . Painting by Anna B. Nash.
- Fig. 3. This represents the dorsum, directly from above. A conspicuous dorid of orange color, with the dorsum mottled everywhere with irregular blotches of dark. The branchial plumes are large and spreading. *Op. cit.*, pl. 22, fig. 2.  $\times 875$ . Painting by Anna B. Nash.

Fig. 2. **Dendrodoris fulva** (MacFarland)  
(Pages 194-196)

- Fig. 2. Dorsal view of living specimen as represented by MacFarland, 1906. *Op. cit.*, pl. 22, fig. 3.  $\times 2$ . Painting by Anna B. Nash.

Fig. 4. **Dendrodoris albopunctata** (Cooper)  
(Pages 196-197)

- Fig. 4. One specimen taken at Bird Rock pools, La Jolla, from which the painting was made; a beautiful small dorid of orange coloring with translucent rhinophore stalks and gill plumes. Each low, rounded papilla is capped with white.  $\times 4$ .





## PLATE 29

Fig. 1. **Laila cockerelli** MacFarland  
(Pages 104-106)

Fig. 1. Anterior view of rhinophore.  $\times 22$ .

Figs. 2, 3. **Ancula pacifica** MacFarland  
(Pages 123-124)

Fig. 2. Left rhinophore turned to show ridge on the front; two processes arising from the base.  $\times 20$ .  
Fig. 3. Division of three-parted gill from above.  $\times 8.5$ .

Figs. 4-6. **Triopha carpenteri** (Stearns)  
(Pages 106-109)

Fig. 4. Profile of rhinophore.  $\times 7.6$ .  
Fig. 5. Front of rhinophore.  $\times 7.6$ .  
Fig. 6. Ventral of head; frontal margin bearing tuberculate papillae; short tentacles auriform, a slit on the upper surface.  $\times 1.2$ .

Figs. 7-10. **Rostanga pulchra** MacFarland  
(Pages 165-169)

Fig. 7. Rhinophore in profile: *p.*, posterior; *a.*, anterior; plates arranged about a central stalk; higher in the posterior.  $\times 31$ .  
Fig. 8. Top view, directly from above, showing the plates arranged about the stalk; edges of triangular plates thickened.  $\times 31$ .  
Fig. 9. Two divisions of the six-parted gill.  $\times 17$ .  
Fig. 10. Ventral view of the head; anterior margin deeply bilabiate, notched in median line, oval tentacles, long and slender, ample mantle.  $\times 5.9$ .

Fig. 11. **Aldisa sanguinea** (Cooper)  
(Pages 169-171)

Fig. 11. Front of rhinophore.  $\times 21.3$ .

Fig. 12. **Cadlina flavomaculata** MacFarland  
(Pages 144-147)

Fig. 12. Posterior face of rhinophore.  $\times 29.7$ .

Figs. 13, 13a. **Cadlina luteomarginata** MacFarland, new name  
(Pages 140-144)

Fig. 13. Front of rhinophore, plate very delicate.  $\times 7.65$ .  
Fig. 13a. A single branch of the gill.  $\times 4.25$ .

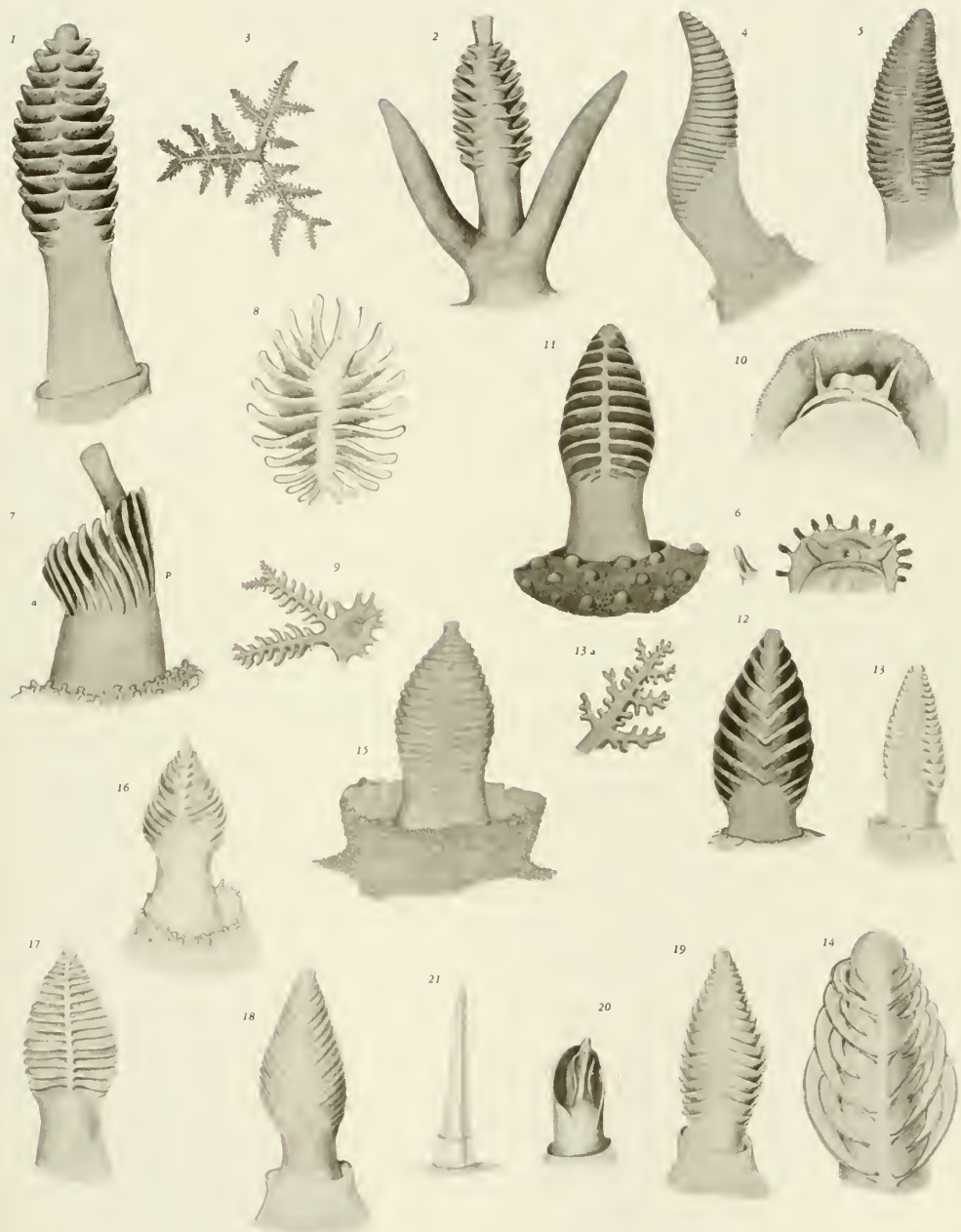




Fig.14. **Austrodoris odhneri** MacFarland, new species  
(Pages 173-179)

- Fig. 14. Camera lucida drawing from mounted rhinophore. The back of the upper third is shown with a slightly undulating ridge; plates alternating with short intermediate leaves.  $\times 14.3$ .

Fig. 15. **Diaulula sandiegensis** (Cooper)  
(Pages 190-192)

- Fig. 15. Front of rhinophore; clavus dilated, deeply retractile into a conspicuous widened sheath.  $\times 7.65$ .

Figs. 16, 17. **Anisodoris nobilis** MacFarland  
(Pages 188-190)

- Fig. 16. Back view of rhinophore, stout with a conical stalk, plates shortened toward the clavus base.  $\times 2.2$ .  
Fig. 17. Front of rhinophore, showing a narrow ridge against which the plates terminate; sheaths low and tuberculate.  $\times 2.2$ .

Figs. 18, 19. **Dendrodoris fulva** MacFarland  
(Pages 194-196)

- Fig. 18. Back of rhinophore, plates shortened at base of clavus.  $\times 6$ .  
Fig. 19. Front, showing slight ridge against which the leaves terminate; sheath with smooth margins.  $\times 6$ .

Fig. 20. **Corambe pacifica** MacFarland and O'Donoghue  
(Pages 130-132)

- Fig. 20. Rhinophore from behind, reproduced from MacFarland and O'Donoghue, 1929. Proc. Calif. Acad. Sci., ser. 4, vol. 18, no. 1, pp. 1-27, pls. 1-3; *o*, outer lamina; *i*, inner lamina.  $\times 15.3$ .

Fig. 21. **Corambella bolini** MacFarland, new species  
(Pages 134-139)

- Fig. 21. Rhinophore slender, smooth, cylindrical stalk retractile into a close, smooth sheath.  $\times 12.9$ .

## PLATE 30

Figs. 1, 2. *Duvaucelia gilberti* MacFarland, new species

(Pages 235-243)

- Fig. 1. Dorsum directly from above; gill tufts on edge of notum extending from right rhinophore sheath, around tail, to sheath of left rhinophore. Alcoholic specimen.  $\times \frac{1}{2}$ .  
Fig. 2. An oblique view, dorsum depressed, left side shows branched gill tufts with feathery tips reflected in the light; head turned, conical processes of veil not well shown, outer margin thickened, rolled into peculiar grooved tentacle. Alcoholic specimen.  $\times \frac{1}{2}$ .

Figs. 3-8. *Duvaucelia tetraquetra* (Pallas)

(Pages 208-218)

- Fig. 3. Slightly oblique view from above; right side. The undulating margins form irregular curves exposing the space above the foot line; gill tufts are excellently preserved, these feathery branches follow the notum margin from right rhinophore sheath to the left one; head veil well shown. Alcoholic specimen.  $\times \frac{1}{2}$ .  
Fig. 4. Ventral side shown, foot smooth, rhinophores protrude from the head. Alcoholic specimen.  $\times \frac{1}{2}$ .  
Fig. 5. Right side exposed; notum and dorsal surface of foot covered with closely set large and small tubercles; dorso-lateral margin fused with rhinophore sheaths on each side, interrupted in front on the inner side. Branched appendages of gill extend around the circumference. Alcoholic specimen.  $\times 9$ .  
Fig. 6. Specimen from above. Rhinophores retracted into sheaths, completely filled by plumes encircling the stalk. Alcoholic specimen.  $\times \frac{1}{2}$ .  
Fig. 7. Ventral view showing the smooth foot strongly contracted; lateral right corner of veil rounded under to the body; mouth with thickened lips. Alcoholic specimen.  $\times \frac{1}{2}$ .  
Fig. 8. Left side of same specimen. Head veil well shown as it passes under the notum to the body. Alcoholic specimen.  $\times \frac{1}{2}$ .

Figs. 9, 10. *Duvaucelia exsulans* (Bergh)

(Pages 226-235)

- Fig. 9. Photograph of specimen from Skogsberg collection, 1930. Very similar in form to the first specimen taken, 1893, described and painted when alive. Figures do not show the contracted frontal veil. A dark protuberance, the rhinophore end, is above two knob-like tubercles of the veil margin. Alcoholic specimen.  $\times 1$ .  
Fig. 10. Slightly different view of same specimen. Prismatic form, pointed tail, branchial plumes all shown. The latter in a contracted state appear as scalloped projections. Alcoholic specimen.  $\times 1$ .

Figs. 11, 12. *Hermaea ornata* MacFarland, new species

(Pages 38-42)

- Fig. 11. Photograph of specimen taken from *Bryopsis*. Right side exposed, animal broadest and highest at the cardiac elevation, margins of notum prominent, bearing closely set, short cerata; numerous, of varying sizes, 50 on each side; longest toward the median line, 4.5 mm. by 0.7 mm. Extending from the reproductive opening is a long bulge in the body wall; a cylindrical sac ending blindly lies under the integument; a seminal receptacle. Frontal margin truncate, rhinophores not well distinguished, tapering tail 4.3 mm. long. Alcoholic specimen.  $\times 3$ .  
Fig. 12. Left side of same specimen. Alcoholic specimen.  $\times 3$ .







Fig. 13. *Dirona albolineata* MacFarland

(Pages 298-302)

- Fig. 13. Photograph, by the author, of small living specimen. Cerata very transparent with an en-crusting white line on the margins.  $\times 2$ .

Figs. 14, 15. *Cadlina modesta* MacFarland, new species

(Pages 147-151)

- Fig. 14. Dorsal view shows proportions of the elliptical dorsum with broad mantle margins, 3 mm., projecting completely beyond the sides of the body. Dorsum completely covered with thickly set rounded tubercles, large and small. The lemon-yellow spots disposed in an irregular line around the margin fade in alcohol; quite pronounced in life. Living specimen.  $\times 2$ . Dimensions: length 19 mm., width 10 mm., foot (ventral) 16 mm.
- Fig. 15. Ventral view shows the narrow, contracted foot; head and oral tentacles; reproductive opening wide extending dorsal margin, all clearly shown. Living specimen.  $\times 2$ .

Fig. 16. *Petelodoris spongicola* MacFarland, new species

(Pages 183-187)

- Fig. 16. Photograph by the author is used to show the character of the integument which is quite thick and rough, thickly set with conical hispid papillae and crowded with interlacing spicules not unlike the surface of the sponge upon which it was found. Living specimen.  $\times 1.8$ .

Fig. 17. *Diaulula sandiegensis* (Cooper)

(Pages 190-192)

- Fig. 17. Photograph by Prof. G. E. MacGinitie of the largest specimen recorded, collected by him in Elkhorn Slough, Monterey Bay, 1942. Living specimen had a total length of 80 mm., by 45 mm. in width, a gill spread of 45 mm. Largest dark ring 10 mm. in diameter. Living specimen.  $\times \frac{1}{2}$ .

## PLATE 31

Figs. 1-5. **Aegires albopunctatus** MacFarland  
(Pages 101-103)

- Fig. 1. Innermost pleural teeth of the sixth row.  $\times 146$ .  
Fig. 2. Four outer pleurae of the 14th row.  $\times 146$ .  
Fig. 3. Fifth and sixth pleurae of the sixth row.  $\times 146$ .  
Fig. 4. The upper mandible; *a*, anterior margin which is thickened.  $\times 36$ .  
Fig. 5. A network of fine spicule-like fibers of the integument; drawing made from the edges of pieces in a permanent mount.  $\times 135$ .

Figs. 6-12. **Laila cockerelli** MacFarland  
(Pages 104-106)

- Fig. 6. Ventral view of the anterior end of the animal; showing head, tentacles, sub-pallial ridge, bilabiate anterior end of foot, reproductive opening, and the numerous marginal papillae.  $\times 2$ .  
Fig. 7. Inner portion of the 60th and 61st rows of the radula: *a*, first pleural tooth; *b*, second pleural tooth; *c*, *d*, third and fourth lateral teeth, uncinial.  $\times 260$ .  
Fig. 8. First and second lateral teeth.  $\times 400$ .  
Fig. 9. Third, fourth, and fifth lateral, uncinial teeth.  $\times 400$ .  
Fig. 10. Two rachidian plates, spurious teeth.  $\times 400$ .  
Fig. 11. Figure of large spicules, probably from the papillae, as those of the dorsal integument show as fine interlacing lines.  $\times 24$ .  
Fig. 12. Isolated hooks from the armature of the glans penis.  $\times 260$ .

Figs. 13-18. **Triopha carpenteri** (Stearns)  
(Pages 106-109)

- Fig. 13. Anterior genital mass of the reproductive system, viewed from the front, *spth.*, spermatheca; *spc.*, spermatocyst; *pr. gl.*, prostate gland; *v. d.*, vas deferens; *amp.*, ampulla; *p.*, penis; *nid.gl.*, nidamental gland.  
Fig. 14. Diagrammatic figure to show the female organs separated from the genital mass. The vagina reaches the vestibule just below the preputial opening. At the proximal end of the vagina is the large spermatheca from which is given off the narrow, long, uterine duct, receiving the spermatocyst before entering the nidamental gland.  $\times 7$ .  
Fig. 15. Thirteenth row of the radula, showing the rachidian teeth of the first and second series, followed by five succeeding pleurae.  $\times 36$ .  
Fig. 16. Rachidian plates of the 18th row.  $\times 52$ .  
Fig. 17. The outermost teeth with the fourth, fifth, and sixth uncinial teeth.  $\times 83$ .  
Fig. 18. Outermost pleurae, seen in front and side view.  $\times 52$ .

Figs. 19-21. **Triopha maculata** MacFarland  
(Pages 109-112)

- Fig. 19. Reproductive complex; posterior face from above. Origin of vas deferens and oviduct, as well as the spermatocyst, is concealed. The usual abbreviations are used.  $\times 7$ .  
Fig. 20. First pleural tooth, outer face.  $\times 83$ .  
Fig. 21. Inner face of the first pleural tooth.  $\times 83$ .





Figs. 22-26. **Triopha grandis** MacFarland

(Pages 112-115)

- Fig. 22. Rachidian plates of tenth transverse row of radula; *a*, plate of the median series; *b*, on the left, plate of the lateral series.  $\times 60$ .  
Fig. 23. Left median rachidian plate of the 14th row.  $\times 60$ .  
Fig. 24. Blunt papilla from the lateral margin of the dorsum, just back of the rhinophore, turned upward and inward toward the mid-dorsum. Within the main tip is a whitish oval area which is probably the "lens" of Fewkes.  $\times 2$ .  
Fig. 25. Oral tentacle; open on the upper surface of the outer half.  $\times 1$ .  
Fig. 26. Isolated hooks from the glans armature.  $\times 260$ .

Figs. 27-31. **Polycera atra** MacFarland

(Pages 115-118)

- Fig. 27. Ventral view of the anterior end of the animal.  $\times 4$ .  
Fig. 28. Reproductive organs in part; *p.*, penis; *amp.*, ampulla of vas deferens; *v.*, vagina; *spth.*, spermatheca; *spc.*, spermatocyst.  $\times 6$ .  
Fig. 29. Mandibles, outer face. The figure shows the normal position of the two parts; ventro-anterior, cutting part and the dorso-lateral, the arched wings of which are broad with the anterior margin concave, the posterior rounded. The minute teeth of the arched cutting portion appear in fine lines.  $\times 15$ .  
Fig. 30. Seventh row of teeth from the radula.  $\times 52$ .  
Fig. 31. Tip of glans penis, showing armature of hooks which extend into the duct of the vas deferens.  $\times 176$ .

Figs. 32-36. **Hopkinsia rosacea** MacFarland

(Pages 125-126)

- Fig. 32. Pleural tooth from the middle of the radula; *a*, inner face; *b*, shows a worn pleural from the anterior end of the radula; *c*, second pleural tooth, displaced.  $\times 60$ .  
Fig. 33. Outer face of the first pleural, the posterior border is beveled to a thin, sharp edge; the anterior margin straight, thick, and rounded. The small hook at the distal end is frequently broken off.  $\times 60$ .  
Fig. 34. Second pleural tooth as seen in side view.  $\times 260$ .  
Fig. 35. Reproductive organs from above and in front. The prostate gland very large. Abbreviations used are the same as for other reproductive figures of this plate.  $\times 6$ .  
Fig. 36. Various branched papillae from the dorsum.  $\times 2$ . Note: Figures 5, 11, 14, 19, 29 are new, the remainder are taken from the plates of the MacFarland, 1906 publication.



## PLATE 32

Figs. 1-12. *Corambella bolini* MacFarland, new species

(Pages 134-139)

- Fig. 1. Outer face, first lateral tooth of radula.  $\times 650$ .  
Fig. 2. Inner face, first lateral. Figures 1 and 2 show the point at the angle of the base and the wing-like prominence.  $\times 650$ .  
Fig. 3. Typical first lateral, inner face, with dimensions indicated; from the lower anterior angle of the base to the point beyond the wing projection, .0275 mm.; vertical height of hook, .024 mm.; height of tooth, base to apex of hook, may reach .047 mm.  $\times 650$ .  
Fig. 4. First lateral seen obliquely from behind and within.  $\times 650$ .  
Fig. 5. Five outer laterals, two to six.  $\times 650$ .  
Fig. 6. Views of top and base of fourth lateral.  $\times 650$ .  
Fig. 7. Two outer laterals as seen in section.  $\times 650$ .  
Fig. 8. Section through the outer lips and inner opening of the pharyngeal bulb. The margin is provided with a thickened cuticular ridge in the ventral side of the opening. Simple pyriform glands, with slender ducts, on the inner side of the lips; with ciliated cuboidal epithelium without. The section passes across ducts of saccular salivary glands which lie on either side of the posterior bulb. The cells of these large glands stain deeply; however the nuclei are clear with small granules.  $\times 212$ .  
Fig. 9. Fourth section beyond the posterior end of the bulb opening; a distinct thickening of the cuticle in the ventral groove extending back to the anterior lower end of the rotella.  $\times 212$ .  
Fig. 10. View of the ventral posterior parts; showing the central larger gill stalk, the outline of the viscera, and the basal gill glands through the integument.  $\times 5$ .  
Fig. 11. An enlarged figure of the central gill stalk which bears three plates on each side; the upper side in view.  $\times 1$ .  
Fig. 12. Rhinophore.

Figs. 13, 14. *Corambe pacifica* MacFarland and O'Donoghue

(Pages 130-132)

- Fig. 13. Inner face of first lateral tooth of the radula.  $\times 580$ .  
Fig. 14. Outer face of first lateral.  $\times 580$ .

Fig. 15. *Acanthodoris lutea* MacFarland

(Pages 120-121)

- Fig. 15. Inner face of first lateral teeth, seventh and eighth half rows of the radula. Outer laterals are seen in the eighth row.  $\times 128$ .

Fig. 16. *Acanthodoris columbina* MacFarland

(Pages 121-123)

- Fig. 16. Inner face of first lateral teeth, seventh and eighth rows, in the eighth the outer laterals are seen.  $\times 128$ .





Figs. 17-24. *Trapania velox* (Cockerell)

(Pages 127-129)

- Fig. 17. Relations of the reproductive conduits in the anterior genital complex. For clearness the mucous and albumen glands are omitted, and the ducts spread apart from the closely packed condition: *h.d.*, hermaphroditic duct from the ovotestis; *h. amp.*, hermaphroditic ampulla; at the anterior end it narrows, dividing into the oviduct and vas deferens, *vas.d.* The latter passes into its prostatic portion, while the oviduct enters the albumen gland. The penis is armed with spines on its inner surface. Upon its emergence from the albumen gland, the uterine duct receives the duct from the spermatocyst and the long duct from the spermatheca; from this the vagina duct arises dilating distally into the vagina.  $\times 20$ .
- Fig. 18. Typical first lateral tooth from the middle region, right side of the radula, seen from above.  $\times 450$ .
- Fig. 19. A similar lateral tooth is seen obliquely from in front and below.  $\times 450$ .
- Fig. 20. The same lateral tooth rotated to the right, showing the external face and part of the base.  $\times 450$ .
- Fig. 21. Inner surface of left mandibular plate, showing its armature.  $\times 122$ .
- Fig. 22. Ventral view of anterior region of the body; showing the slender foot, the angles produced into long processes and the narrow ridge along the lateral margins.  $\times 6$ .
- Fig. 23. A detailed drawing of the central gill plume, bipinnate or simple pinnate, non-retractile.  $\times 12$ .
- Fig. 24. The enlarged rhinophore is shown in a slightly oblique view. The central ridge is marked and the plates very thin.  $\times 12$ .

Figures 17 to 24 redrawn in part from MacFarland, 1929. Proc. Calif. Acad. Sci., ser. 4, vol. 18, pl. 35.

## PLATE 33

Figs. 1-11. *Cadlina luteomarginata* MacFarland, new name  
(Pages 140-144)

- Fig. 1. Thirty-sixth row of radula; median tooth, one lateral on the left, three laterals on the right.  $\times 220$ .  
Fig. 2. Three teeth; median and one lateral rotated to show the inner margins.  $\times 220$ .  
Fig. 3. Outermost four teeth, base showing.  $\times 320$ .  
Fig. 4. Eleventh lateral from the 13th row, outer face.  $\times 144$ .  
Fig. 5. An outer tooth showing base.  $\times 320$ .  
Fig. 6. The outer face of the 44th lateral from the 29th row.  $\times 144$ .  
Fig. 7. Labial rodlets showing curve and bifid tips.  $\times 390$ .  
Fig. 8. Labial rodlets from the mouth armature as seen from above.  $\times 390$ .  
Fig. 9. Reproductive system, parts in their natural relations.  $\times 8.5$ .  
Fig. 10. Cross section of papilla from the side of the notum; there is a dense interlacing of spicules.  $\times 55$ .  
Fig. 11. Section of large papilla from the notum edge with full-length spicules protruding from the surface.  $\times 156$ .

Figs. 12-21. *Cadlina flavomaculata* MacFarland  
(Pages 144-147)

- Fig. 12. Thirty-second and 33rd rows of the radula, each with a median tooth and two laterals, the second lateral on the right rotated inward, giving a profile view.  $\times 390$ .  
Fig. 13. Fourth lateral, outer face.  $\times 390$ .  
Fig. 14. Lateral, midway of row.  $\times 390$ .  
Fig. 15. Outermost lateral tooth.  $\times 390$ .  
Fig. 16. Rodlets of labial armature above the epithelium.  $\times 390$ .  
Fig. 17. Labial rodlets, slightly curved with deeply cleft tips.  $\times 83$ .  
Fig. 18. Dorsal view of reproductive system.  $\times 7.5$ .  
Fig. 19. Detail of the ducts entering the vagina.  $\times 10$ .  
Fig. 20. Armature of the vas deferens, protruding through the glans penis.  $\times 22$ .  
Fig. 21. Armature of the spines under higher magnification.  $\times 260$ .

Figs. 22-31. *Cadlina modesta* MacFarland, new species  
(Pages 147-151)

- Fig. 22. A row from the radula showing the median tooth and two laterals on either side.  $\times 390$ .  
Fig. 23. Outer face of third, fourth, and fifth laterals obliquely from above, showing the increase in the size of the cusp and the number of denticles.  $\times 390$ .  
Fig. 24. Outer face of third lateral.  $\times 390$ .  
Fig. 25. The 11th lateral shows the rapid increase in the length of the cusp.  $\times 390$ .  
Fig. 26. Outermost lateral, reduced to a slender straight spine with minute denticles.  $\times 390$ .  
Fig. 27. Three rodlets from the labial armature, front view.  $\times 390$ .  
Fig. 28. An oblique view of rodlets.  $\times 390$ .  
Fig. 29. The reproductive complex. "The author was completing his work on the new species. He had finished the dissection and the camera-lucida drawings of the parts of the complex; these he checked the day before his death. The completed figure as here presented, shows the parts as he had assembled them.  $\times 18$ ." O. H. MacF.  
Fig. 30. Armature of spines on the inside of the duct of the vas deferens  $\times 180$ ; *a*, shows three enlarged spines.  $\times 260$ .

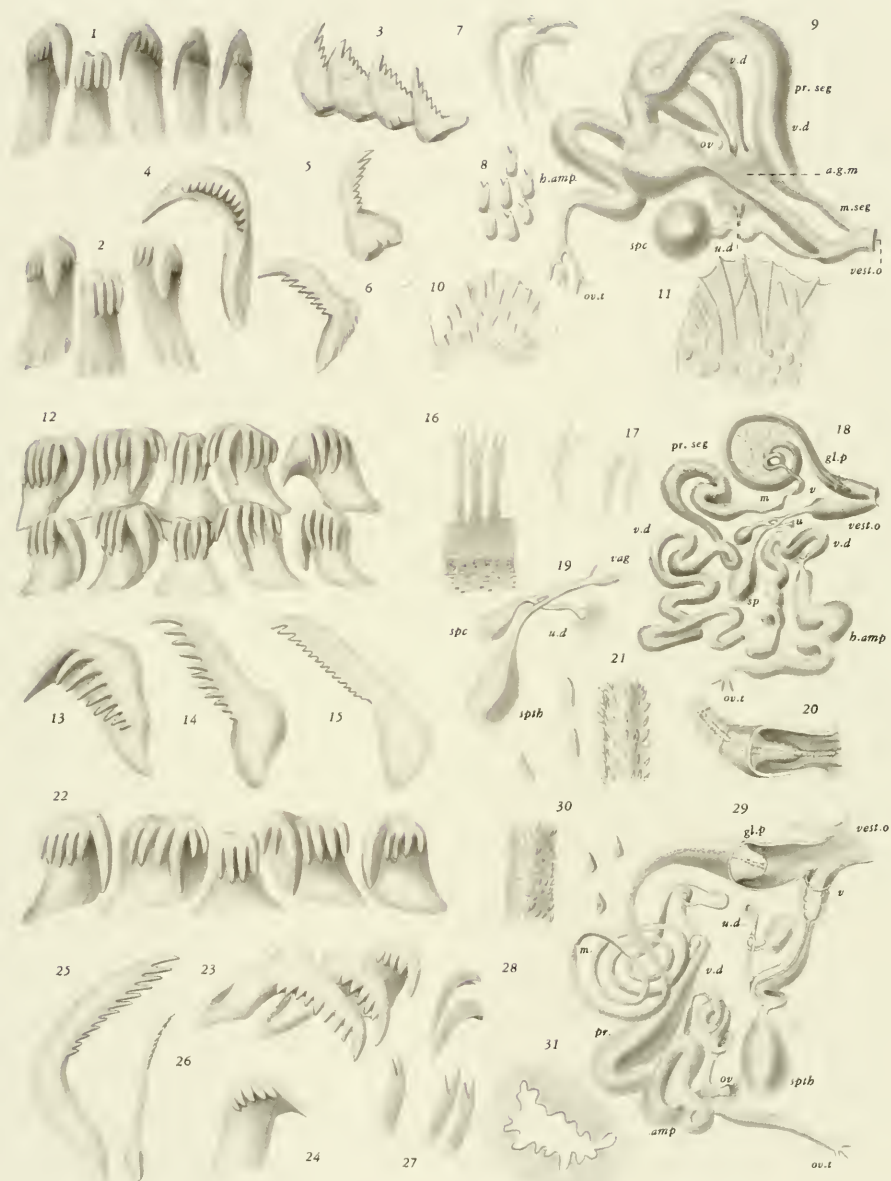






Fig. 31. Cross section of the vagina to show the greatly folded epithelial lining, bearing a thick cuticle.  $\times 390$ .

List of abbreviations used in lettering the figures of the reproductive systems. These follow in order from the ovotestis through to the external openings.

<i>ov.t.</i> ,	ovotestis
<i>sm.h.d.</i> ,	small hermaphroditic duct
<i>h.amp.</i> ,	hermaphroditic ampulla
<i>a.g.m.</i> ,	adnexed genital mass
<i>nid.gl.</i> ,	nidamental gland
<i>ov.</i> ,	oviduct
<i>vas.d.</i> ,	vas deferens
<i>pr.seg.</i> ,	prostatic segment
<i>m.seg.</i> ,	muscular segment
<i>p.</i> ,	preputium
<i>gl.p.</i> ,	glans penis
<i>vag.</i> ,	vagina
<i>spth.</i> ,	spermatotheca
<i>spc.</i> ,	spermatocyst
<i>u.d.</i> ,	uterine duct
<i>vest.o.</i> ,	vestibular opening

## PLATE 34

Figs. 1-11. *Glossodoris macfarlandi* (Cockerell)

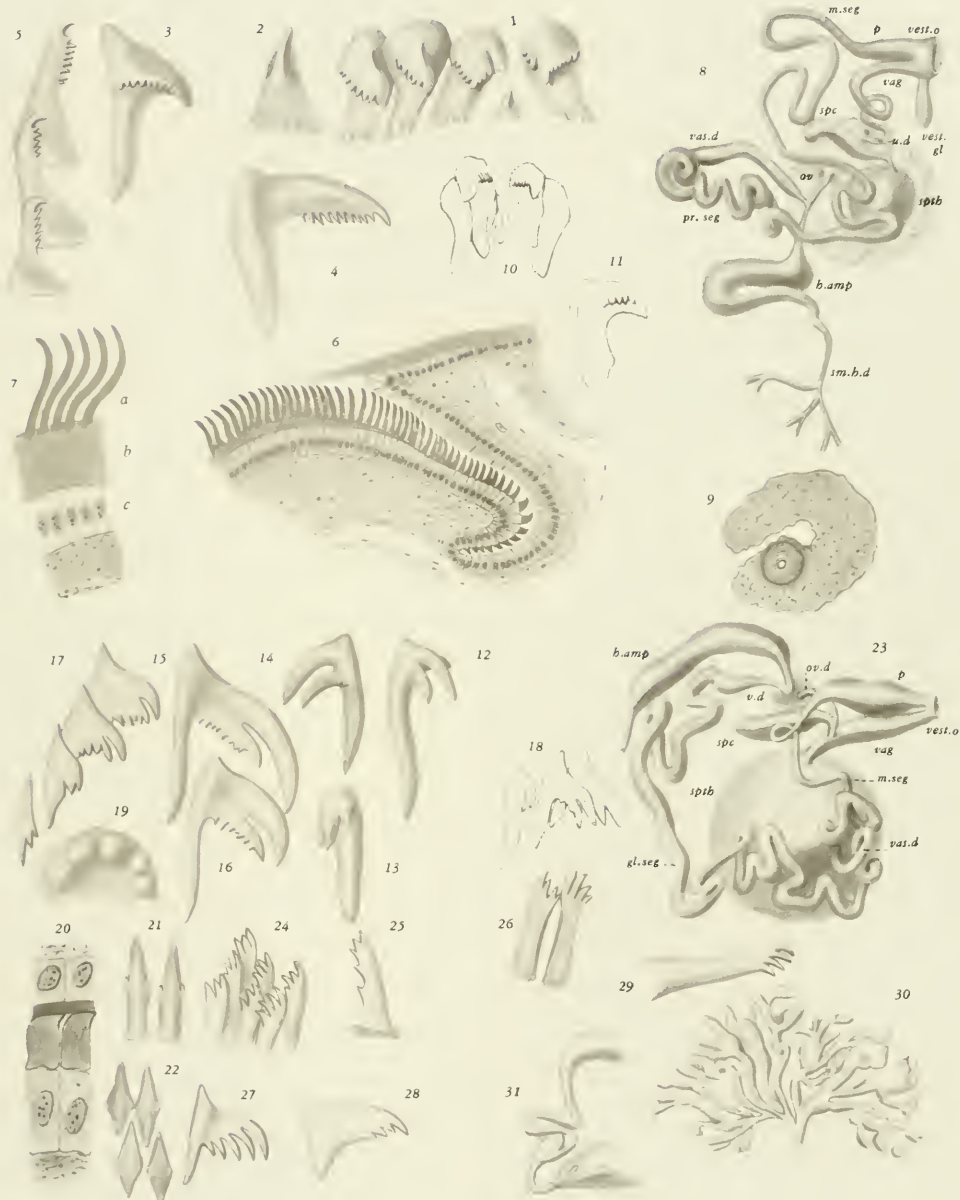
(Pages 153-157)

- Fig. 1. From the 20th row of the radula; median tooth, first lateral to the right, first three laterals on the left.  $\times 530$ .
- Fig. 2. Median tooth under high magnification, central cusp erect and pointed, margin of the base thin and jagged.  $\times 880$ .
- Fig. 3. Outer face of the first lateral from the tenth row, seen obliquely with large hooked cusp and small denticles.  $\times 530$ .
- Fig. 4. Profile view, outer face of the 12th lateral; shows full length of hook and base.  $\times 530$ .
- Fig. 5. Three outermost teeth.  $\times 530$ .
- Fig. 6. Sectional drawing from a horizontal series through the labial armature, showing the development of the rodlets from the follicular groove to the full rodlets at the front margin, each arising from its epithelial cell with the bases united by the homogeneous cuticle.  $\times 135$ .
- Fig. 7. Detailed figure of a group of rodlets near the front margin, *a*, layer of homogeneous cuticle at *b*, and the epithelial cells at *c*.  $\times 440$ .
- Fig. 8. Figure showing the reproductive complex; the parts are designated in order, from the ootestis: *sm.h.d.*, small hermaphroditic duct; *h.amp.*, hermaphroditic ampulla; *ov.*, ovi-duct; *vas.d.*, glandular vas deferens; *p.*, preputium; *vest.o.*, vestibular opening; *vest.gl.*, vestibular gland; *vag.*, vagina; *u.d.*, uterine duct; *spc.*, spermatocyst; *spth.*, spermatheca.  $\times 12$ .
- Fig. 9. Oblique section through the vestibular gland, the gland was curved, but the muscular duct appears.  $\times 17$ .
- Fig. 10. Tracing from Bergh, 1880. (Proc. Acad. Nat. Sci. Philadelphia, pl. 14, fig. 2.) *Chromodoris dalli* showing the median tooth and two laterals.  $\times 750$ .
- Fig. 11. Tracing from Bergh. reference as above, pl. 13, fig. 13; profile of the 13th tooth.  $\times 750$ .

Figs. 12-23. *Chromodoris californiensis* Bergh

(Pages 157-162)

- Fig. 12. First lateral tooth of the radula, outer face.  $\times 398$ .
- Fig. 13. First lateral, inner face, viewed obliquely.  $\times 398$ .
- Fig. 14. Third lateral, outer face, two small denticles at the base of the lateral denticle.  $\times 398$ .
- Fig. 15. Eightieth lateral; profile view of large cusp, lateral with small denticles, together forming a large hook.  $\times 398$ .
- Fig. 16. Thirtieth tooth in the 50th row.  $\times 398$ .
- Fig. 17. Four outermost laterals which maintain the same form, gradually reduced to a thin plate.  $\times 486$ .
- Fig. 18. Tracings from Bergh, three outermost laterals, *Chromodoris californiensis*; 1880, *op. cit.*, pl. 14, fig. 11.  $\times 750$ .
- Fig. 19. Tracing from Bergh, 1880, nodules under hinder part of the mantle, same reference as above, figure 5.  $\times 750$ .
- Fig. 20. Section from a longitudinal series of the labial armature. This passes through two rodlets just anterior of the sulcus margin within the groove; epithelium below, above the outer cuticle which lies in contact with the upper cuboidal epithelium of the sulcus.  $\times 650$ .  
See figure 6 of *Glossodoris macfarlandi*.
- Fig. 21. Two rodlets, labial armature, anterior margin.  $\times 880$ .
- Fig. 22. Four elements, seen from above showing pavement formation, bifid tips very rare.  $\times 880$ .
- Fig. 23. Figure of reproductive complex; *h.amp.*, hermaphroditic ampulla along tubular duct enters the nidamental gland, by a very short duct emerging near its entrance as the *vas.d.*, vas deferens, which has a very long, convoluted, glandular segment followed by the narrow muscular one leading through the preputium to the external opening. The *ov.d.*,





oviduct, arising from the nidamental gland, receives the short duct of the *spc.*, spermatocyst, and enters the vagina. Near its connection with the *spth.*, spermatheca, the vagina reaches the vestibule just below the preputial opening.  $\times 6$ .

Figs. 24-31. **Chromodoris porterae** Cockerell  
(Pages 163-165)

- Fig. 24. Group of lateral teeth from the radula, viewed from above on the forked tips.  $\times 650$ .  
Fig. 25. Lateral tooth from the outer margin, base showing.  $\times 650$ .  
Fig. 26. Face view, two rodlets; height .022 mm.; width of base .005 mm.  $\times 650$ .  
Fig. 27. Profile view of 12th lateral tooth, outer face; cusp bifid at the tip.  $\times 870$ .  
Fig. 28. Lateral tooth near the margin.  $\times 870$ .  
Fig. 29. One rodlet from the mandibular armature, showing paw-like tip with four sharp points on the sharp denticles.  $\times 650$ .  
Fig. 30. Vestibular gland; made up of interlacing tubules originating from the branching of a single duct leading into the genital vestibule close to the external opening of the oviduct.  $\times 20$ .  
Fig. 31. Anterior of the reproductive complex; loop of the glandular segment of the vas deferens followed by the muscular segment; at the base of the preputium, upon entering, the duct describes a loop before passing to the external opening.  $\times 15$ .



## PLATE 35

Figs. 1-16. *Rostanga pulchra* MacFarland

(Pages 165-169)

- Fig. 1. The drawing includes the first seven pleural teeth of the radula; the teeth so placed to be seen at slightly different angles.  $\times 650$ . In *a*, higher magnification of the first tooth, which is thick and stout with 8 to 11 denticles. The succeeding 10 all have a strong broad base with a strong thick cusp.  $\times 880$ .
- Fig. 2. The 11th and 12th laterals in profile view; the hook lengthens, becoming more slender.  $\times 650$ .
- Fig. 3. The 15th tooth seen obliquely, showing the wide base.  $\times 650$ .
- Fig. 4. The 27th tooth in profile; a rectangular base from one corner of which the shaft arises, in a broad sickle-like curve.  $\times 650$ .
- Fig. 5. The flattened base of the same tooth, seen from above.  $\times 650$ .
- Fig. 6. The 30th tooth becomes more erect and slender.  $\times 400$ .
- Fig. 7. Outermost pleural in the row, seen in profile; the outer teeth become long slender elements, each with a small compressed wing-like base; the long but slightly curved hook bears, distally, from one to six denticles on the outer margin.  $\times 400$ .
- Fig. 8. Distal, outermost third of the tooth under high magnification; denticles increase in length from within outward and give the tooth the appearance of being divided.  $\times 670$ .
- Fig. 9. Labial armature seen from above; a crescentic band of flattened rodlets on either side of the mouth opening, elements in closely overlapping rows, curving forward.  $\times 650$ .
- Fig. 10. Sectional view through three elements, showing the outline in profile.  $\times 650$ .
- Fig. 11. Cross section of the oral cavity; a cuticular lining is found throughout, the armature elements line the dorsal region.  $\times 45$ .
- Fig. 12. Drawing shows a section through the hinder margin of the armature, seen clearly at *a*.  $\times 45$ .
- Fig. 13. Two elements from the armature in the region *a*, figure 12.  $\times 650$ .
- Fig. 14. A group of three papillae, *a*, *b*, *c*, from the notum which is completely covered by these. They vary only in size, each being supported by a number of divergent straight spicules from the integument below the base. These pass to the margin, which is elevated by them into pointed projections. The center being sunken below. A single layer of epithelium follows the spicule; *a*, *b*  $\times 64$ , *c*  $\times 134$ .
- Fig. 15. Group of spicules from the integument which are of various shapes, *a*, *b*, *c*.  $\times 74$ .
- Fig. 16. Figure shows the vagina, passing inward beneath the spermatocyst, connecting with the large spermatheca on its median face; a duct emerges beside this, passing directly to the spermatocyst, giving off the uterine duct which enters the gland complex.  $\times 8$ .

Figures 9-16 are new; the remainder are from MacFarland, 1906. Bull. U. S. Bureau of Fisheries, vol. 25, pl. 18.

Figs. 17-22. *Aldisa sanguinea* (Cooper)

(Pages 169-171)

- Fig. 17. Four outer pleural teeth which are the shorter, ranging down to .03 mm. in height, with overlapping, compressed, triangular bases.  $\times 650$ .
- Fig. 18. Pleural tooth from the inner radula. Figure shows only the distal one-third of its length. These elements are very flexible and easily disarranged. The distal margin seems to be notched.  $\times 650$ .
- Fig. 19. Cross section from the pharyngeal bulb showing the thick cuticle at *a*, which is continued into the dorsal region of the oral cavity. In this area the cuticle appears divided into an armature of very small rodlets, one arising from each epithelial cell, seen at *b*.  $\times 650$ .
- Fig. 20. Reproductive system. The ampulla and prostate gland rest upon the very large spermatheca; the narrow, muscular vas deferens passes to the preputium; the vagina passing from the spermatheca and spermatocyst opens beside the penis.  $\times 22$ .





- Fig. 21. The longitudinal section passes through the distal end of the penis as it opens from the preputium. At the tip of the penis can be seen the duct of the vas deferens which has an armature of hooks extending within; being eversible.  $\times 135$ .  
Fig. 22. Armature spines within the vas deferens.  $\times 650$ .

Figures 19-22 are new; the remainder are from MacFarland, 1906, *op. cit.*, pl. 18.

**Figs. 23-25. *Diaulula sandiegensis* (Cooper)**

(Pages 190-192)

- Fig. 23. Five innermost pleural teeth.  $\times 83$ .  
Fig. 24. Six outermost pleural teeth; margin of the wing indicated.  $\times 83$ .  
Fig. 25. Profile view of single pleural tooth from the middle of the row; showing the wing on the inner margin, long hook; point on the base.  $\times 242$ .

Figures 23-25 are traced from MacFarland, 1906, *op. cit.*, pl. 18.

**Figs. 26-33. *Discodoris heathi* MacFarland**

(Pages 192-193)

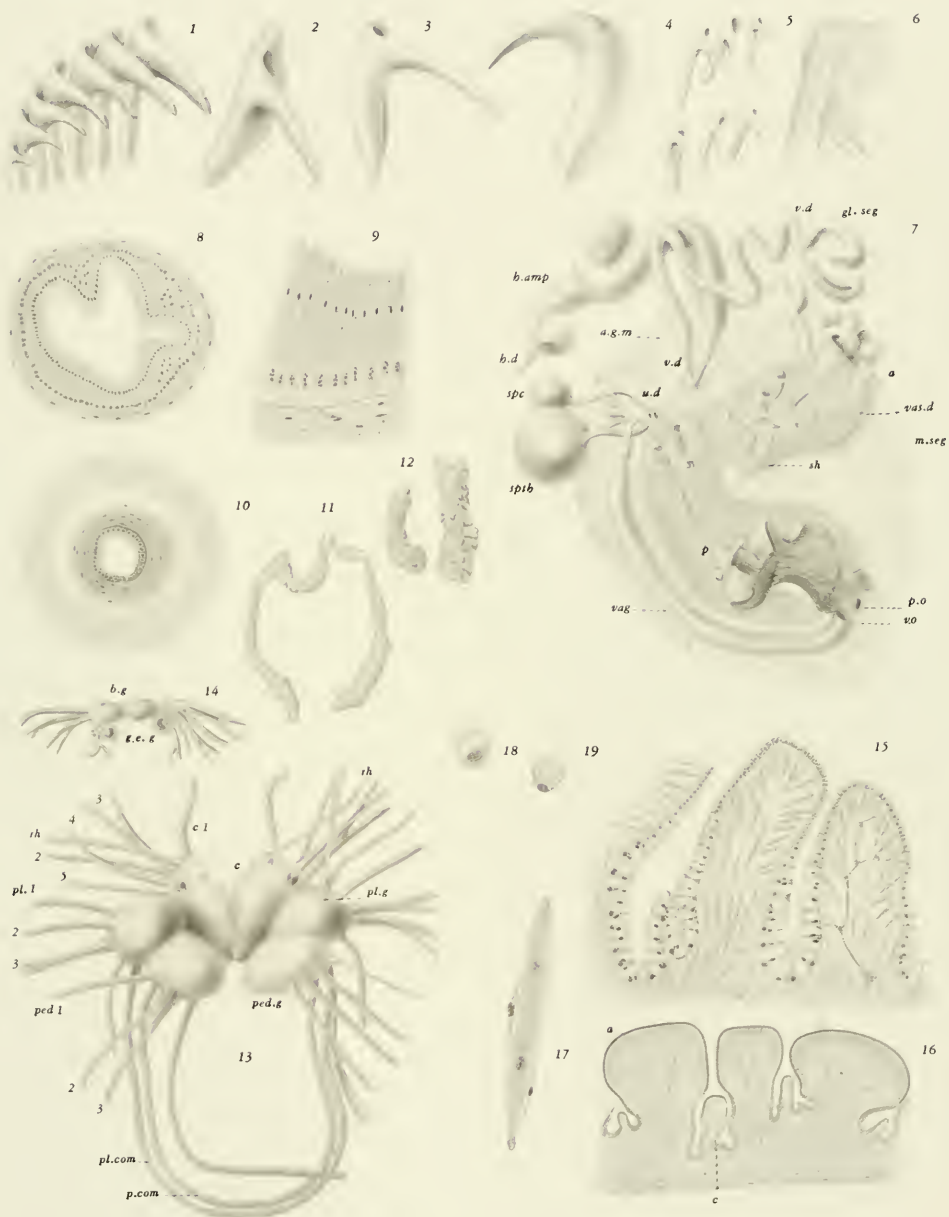
- Fig. 26. Ventral view of the head region.  $\times 3$ .  
Fig. 27. Six inner pleural teeth from the 12th row. Distal two-thirds of the shaft is shown with its strong hook, wide wing on the inner margin which lies beneath the adjacent tooth.  $\times 146$ .  
Fig. 28. The outermost group of four teeth; (the following few omitted); the remaining five being toward the center of the row.  $\times 148$ .  
Fig. 29. The inner face of a typical pleural tooth.  $\times 83$ .  
Fig. 30. Outlines of labial armature disk in their natural relations. Minute rodlets are indicated in the two areas which are quite distinct.  $\times 24$ .  
Fig. 31. Figure shows rodlets under higher magnification; these increase in length from the lower to the upper margin; a group extends beyond the margin. Rodlets very slender with squared ends.  $\times 386$ .  
Fig. 32. Female genital organs; *vag. d.*, vaginal duct; *spth.*, spermatheca; *u.d.*, uterine duct; *spc.*, spermatocyst.  $\times 25$ .  
Fig. 33. Male genital parts; from the distal end of the ampulla the oviduct passes into the gland mass, the vas deferens enlarges into its prostatic segment, from the distal end the narrow muscular duct passes to the preputium.  $\times 25$ .

## PLATE 36

Figs. 1-19. *Austrodoris odhneri* MacFarland, new species

(Pages 173-179)

- Fig. 1. Seven teeth from the outer margin of the radula.  $\times 6$ .  
Fig. 2. Twenty-ninth lateral tooth, oblique view.  $\times 64$ .  
Fig. 3. Outer face of lateral tooth, seen in profile.  $\times 64$ .  
Fig. 4. Inner face of lateral, the profile, showing the thin wide wing on the posterior border of the base.  $\times 64$ .  
Fig. 5. Three displaced innermost teeth seen at different angles.  $\times 64$ .  
Fig. 6. Ventral view of the 22nd and 23rd teeth.  $\times 64$ .  
Fig. 7. Reproductive system. The genital complex lies close in front of the right liver lobe. It is a flattened ellipsoid in form. The large convolutions of the mucous gland, *m.gl.*, form an almost complete ring encircling it. These convolutions, in the figure, are represented by a slightly shaded portion. The small hermaphroditic duct dilates at once into the ampulla, *h. amp.*, a convoluted widened duct. This narrows, entering the cavity of the complex. The vas deferens, *vas. d.*, emerges, passing into its glandular segment, *gl. seg.* At the point marked *a*, this suddenly narrows, passing into an enveloping sheath of fibrous tissue. The many windings of the narrow muscular segment, *m. seg.*, are thus enveloped until the papilla is reached. This guards the genital cloaca leading to the external opening. The vaginal opening, *v. o.*, lies close to the male one. The long incompletely divided lumen leads proximally to its narrowed duct receiving the spermatheca, *sph.*, and spermatheca, *spc.*, continuing as the short uterine duct, *u. d.*, into the nidamental gland cavity.  $\times 6$ .  
Fig. 8. Cross section of the glandular segment of the vas deferens, the irregular lumen due to ridges in the ciliated epithelium.  $\times 64$ .  
Fig. 9. A segment of the same section under high magnification. Two types of cells are in the wall, glandular and interstitial, the latter having small nuclei bearing long cilia.  $\times 215$ .  
Fig. 10. This shows a cross section of the narrow muscular segment of the vas deferens.  $\times 64$ .  
Fig. 11. Salivary glands, finely lobulate, band-like.  $\times 2.7$ .  
Fig. 12. Anterior end of the lobulated blood glands found on the dorsal side of the pharyngeal bulb.  $\times 2.7$ .  
Fig. 13. Central nervous system. Camera-lucida drawing from a mounted preparation; shows cerebral, pleural, and pedal ganglia; the principal nerves from each are indicated on one side only.  $\times 7$ .  
Fig. 14. Buccal ganglia, united to the cerebral by relatively long connectives, closely united to these are the gastro-oesophageal ganglia containing one large nerve cell body and a number of small ones.  $\times 7$ .  
Fig. 15. Figure of integumental glands, showing large papillae; calcareous spicules arrange themselves directly below the epithelial surface radiating toward it. Lower in the integument, these interlace at various angles.  $\times 40$ .  
Fig. 16. Closely set tubercles of the notum, large flat ones are shown. Tubercular glands open into the grooves between the tubercles, at *a*, to the columnar form found in the glands at *c*.  $\times 40$ .  
Fig. 17. Thick celloidin sections were used to study the structure of the spicules; a light stain haematoxylin differentiated the parts. A spindle-shaped figure is shown, the calcareous portion forms a thin, hollow, highly refringent peripheral layer surrounding a central cavity filled, presumably, with faint staining cytoplasm and an axial elongated nucleus. Over the external surface appears to be a very thin layer of cytoplasm.  $\times 330$ .  
Fig. 18. Cross section of a spicule through the nucleus of the central substance.  $\times 330$ .  
Fig. 19. This section shows the outer layer and nucleus above the calcareous layer.  $\times 330$ .





## PLATE 37

Figs. 1-10. *Archidoris montereyensis* (Cooper)

(Pages 181-182)

- Fig. 1. Three outermost lateral teeth from the radula, row 18.  $\times 64$ .  
Fig. 2. Outer faces of two laterals.  $\times 64$ .  
Fig. 3. Innermost three laterals.  $\times 64$ .  
Fig. 4. Inner face of the 12th pleural tooth of the fourth row, wide wing in profile.  $\times 64$ .  
Fig. 5. Inner face of small lateral showing long hook and pointed tip of wing-like expansion on the inner margin.  $\times 64$ .  
Fig. 6. Outer face of 22nd tooth of the sixth row, surface convex, wing flat and thin.  $\times 64$ .  
Fig. 7. Inner face of an isolated tooth from the middle of row, wing rotated inward.  $\times 64$ .  
Fig. 8. Ventral view of anterior end of animal, life size.  $\times 64$ .  
Fig. 9. The male genital organs are shown. The small hermaphroditic duct widens abruptly into the hermaphroditic ampulla, an irregular convoluted duct which narrows, giving off the oviduct, entering the genital cavity, and the vas deferens a long winding tube leading to the preputium. Through this the external opening is reached.  $\times 5$ .  
Fig. 10. This figure pictures the female organs of the complex from the vaginal opening which is just below that of the preputium. From the vagina its duct passes inward, wide and convoluted, receiving the duct of the spermatheca; the duct of the spermatocyst also enters at the junction with the uterine duct.  $\times 10$ .

Figs. 11-21. *Petelodoris spongicola* MacFarland, new species

(Pages 183-187)

- Fig. 11. Five outermost lateral teeth.  $\times 110$ .  
Fig. 12. Four outermost teeth from a younger row.  $\times 120$ .  
Fig. 13. Four teeth from the outside of the ninth row.  $\times 120$ .  
Fig. 14. Thirteenth and 14th teeth from the 11th row, front view.  $\times 110$ .  
Fig. 15. Three laterals, oblique view, outer surface, 11th row.  $\times 110$ .  
Fig. 16. Sixth lateral, from the group of figure 15, reversed, showing the inner concave surface, with narrow wing.  $\times 110$ .  
Fig. 17. Base of lateral tooth.  $\times 110$ .  
Fig. 18. First and second laterals.  $\times 110$ .  
Fig. 19. One papilla from the notum strengthened by three large spicules protruding from the surface.  $\times 70$ .  
Fig. 20. Detail of structure of one spicule from longitudinal section, finely lamellate, at the ends the cavity is bridged by numerous, very thin, convex partitions.  $\times 215$ .  
Fig. 21. Detail from serial sections of one spicule with its overlying epithelium modified over the tip with very flattened cells; a nucleus is figured in the center.  $\times 530$ .

Figs. 22-27. *Anisodoris nobilis* MacFarland

(Pages 188-190)

- Fig. 22. Outermost lateral teeth from the sixth row.  $\times 64$ .  
Fig. 23. First five innermost teeth of the first row, inner face, concave surface, thickened wing-like edge.  $\times 64$ .  
Fig. 24. Twenty-first to the 24th lateral teeth, showing the regularity of the hooks; the very thin transparent margins of the base.  $\times 64$ .  
Fig. 25. Outer face, 30th tooth, 20th row, profile view, wing on edge of inner face.  $\times 64$ .  
Fig. 26. Ventral, anterior end of animal, life size.  
Fig. 27. Reproductive complex. Camera-lucida drawing of a dissection. The large hermaphroditic ampulla narrows and divides into the oviduct and vas deferens; the latter entering the prostatic gland at once, from which it passes into its very long, narrow, muscular segment, entering the glans penis in the preputial cavity to the external opening. The vaginal opening lies just below. The vaginal duct passing inward receives the duct of the large spermatheca near the connection of the uterine duct. This duct, arising from the nidamental gland, receives the duct from the spermatocyst midway of its length.  $\times 3.5$ .



## PLATE 38

Figs. 1-6. *Armina californica* (Cooper)

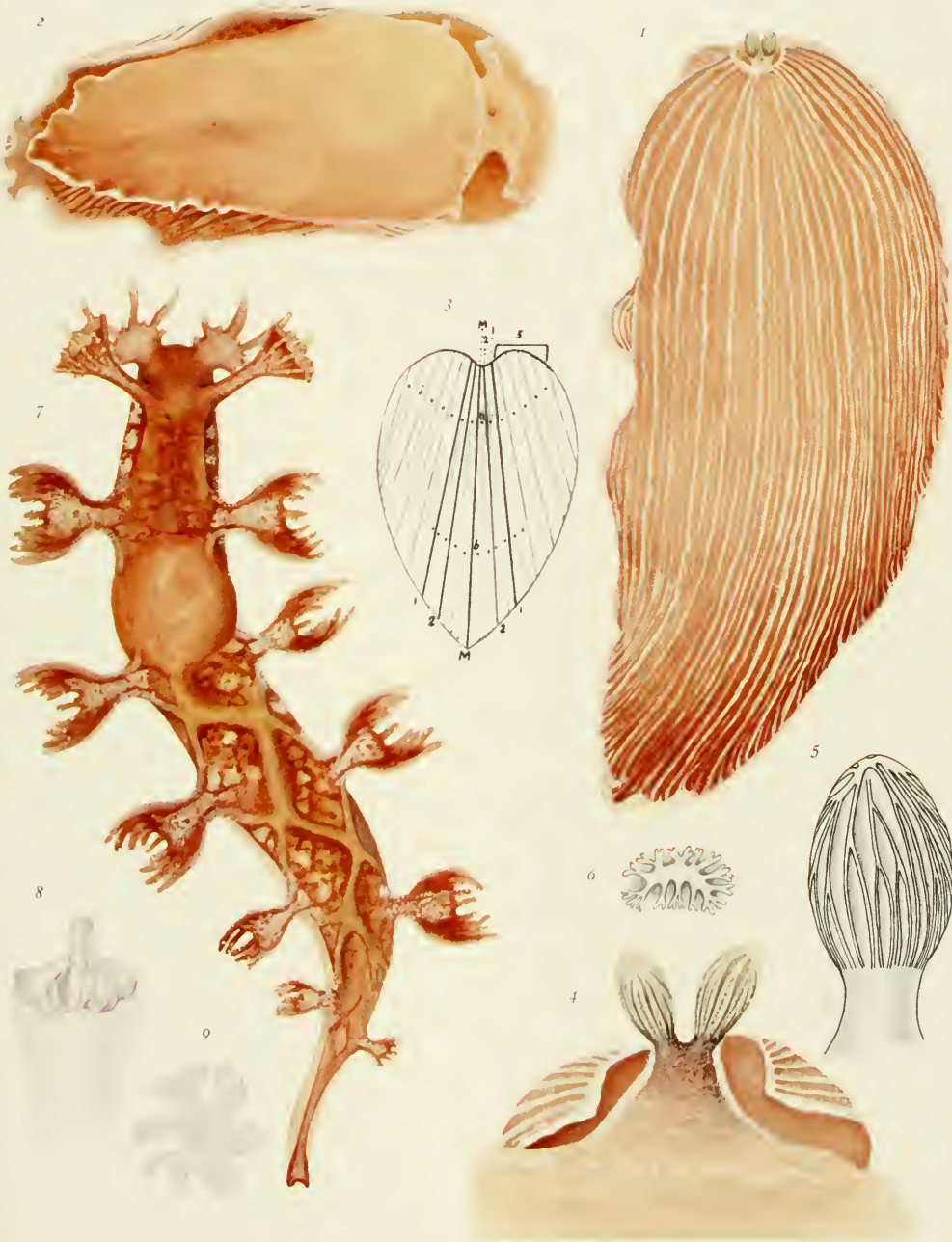
(Pages 198-206)

- Fig. 1. Dorsal view of specimen 50 mm. long is here represented; the undulating margins of the mantle, its color and the many linear white lines, are quite true to the living specimen. Accuracy of proportions about the head, the placing of the lines arising from the notch, are not correct. A diagram has been made, following the description in the manuscript. Painting by Anna B. Nash.  $\times 2.5$ .
- Fig. 2. Painting of ventral side to show the color and texture of the integument. Head shield is well shown, thrown forward showing the mouth. An indication of pustule-like elevations on the underside of the left outer margin can be seen. On the right, within the region of these, are indicated oblique thickened ridges back of the anterior branchial lamellae. Painting by Anna B. Nash.  $\times 2$ .
- Fig. 3. A diagram to show the distribution of the white lines on the dorsum. Principal lines are a median, *m*; two laterals, one on either side, *l*; originating from the anterior notch, passing backward uninterrupted. Lateral to the notch are five to eight similar lines arising from the anterior margin, passing backward, diverging and terminating at intervals along the posterior lateral margins of the mantle. Alternating with the innermost primary lines are three to four secondary ones, *a*, appearing faintly at about one-fifth the length of the dorsum. A third series, *b*, alternating in the center appear in the posterior third of the dorsum.
- Fig. 4. As seen from directly in front, showing the shape and colors of the rhinophores. In the remainder of the drawing no attempt was made to be accurate; the wavy white line indicates the dorsal edge of the head shield, not shown; the cavity of the rhinophores not indicated. Painting by Anna B. Nash.  $\times 16.5$ .
- Fig. 5. Inner side of the rhinophore, flattened medially and rounded externally; thick, flat, vertical plates are exactly drawn; the grooves are quite deep.  $\times 25$ .
- Fig. 6. Outline of the oval head of the same rhinophore is represented as flattened in order to show primary and secondary ridges over the curved edge. The primary ones originate on the ovoid head, and split up into secondary ridges on the lower half of the clavus; deep grooves separate the primary ones.  $\times 25$ .

Figs. 7-9. *Hancockia californica* MacFarland

(Pages 246-254)

- Fig. 7. Dorsal view; many specimens were studied over a period of years. In Monterey Bay the species occurs in two colorings; first, a deep clear garnet red showing as pale lavender in the young; second, a soft neutral green, in the young a light gray. The liver branches carry the red, brown, green of the algae upon which they feed. The general integument, a cream color, serves as a background and transparent medium for the bold network of blood vessels, the intricate branchings to the cerata and minute details of surface spots and patterns. A dusting of white points, in a definite pattern, is found on the convex dorsal surface of cerata; the numerous cnidosacs of the cerata and rhinophores are marked by rounded heavy dots of white.  $\times 8.3$ .
- Fig. 8. Figure of the rhinophore showing the distal margin of the calciform sheath; tip of the clavus, rising above, bears six main plates, or leaves, standing at right angles to the surface of the tip.  $\times 10$ .
- Fig. 9. An outline of cross section of the perfoliate rhinophore, passing through six main leaves from which subdivisions arise.  $\times 60$ .



## PLATE 39

Figs. 1-6. *Duvaucelia festiva* Stearns

(Pages 218-226)

- Fig. 1. Profile view of specimen 35 mm. long; animal very delicate, clear, and transparent. Gill plumes borne along the dorsal lateral margin, alternating large and small, decreasing in size as the tail is reached; a pattern of thick, opaque, white lines covers the dorsum in a striking and constant design.  $\times 4.8$ .
- Fig. 2. Dorsal view directly from above; the pattern of thick, opaque, white lines is clearly followed in its intricate loops; a slight indication of fine network is seen on the posterior dorsum; the transparency of the foot beyond the sides is well shown; the rhinophore stalks are too long and the sheaths should flare as in figure 1. Painting by Anna B. Nash.  $\times 5$ .
- Fig. 3. Detailed figure of ventral aspect of head parts greatly extended; front margin of foot rounded, very slightly bilabiate, ventral sides of velar processes and anterior tentacles show the deep grooves their entire length; mouth small with rounded lips.  $\times 4.7$ .
- Fig. 4. Detail of rhinophore to show flaring sheath, truncate clavus, pinnate and bipinnate plumes in close clusters, the hindermost one adnate to the stalk throughout its full extent.  $\times 16.7$ .
- Fig. 5. Detail of large gill plume from the highest point of the loop of white along the edge of the dorsum; strong, tapering, erect trunk which divides into a number of spreading branches, bipinnate on their margins.  $\times 9.2$ .
- Fig. 6. One branch of gill highly magnified to show the manner of division and the thickness of the edges.  $\times 25$ .

Fig. 7. *Duvaucelia exsulans* (Bergh)

(Pages 226-235)

- Fig. 7. Painting of Monterey specimen, 50 mm. long, 16 mm. wide; made when first taken from the water; used as a record of colors and form. The perpendicular sides give the animal a squarish appearance. Color and form very accurate for the species. The only living specimen ever received by the author. Painting by Anna B. Nash.  $\times 1.67$ .

Figs. 8-10. *Duvaucelia tetraquetra* (Pallas)

(Pages 208-218)

- Fig. 8. Pencil drawing of a living specimen 150 mm. long from Monterey Bay. This shows a lateral view of the rhinophores and the external margin of the sheath which is fused with the dorso-lateral margin of the notum. This bears an irregular series of low, tripinnate, branchial appendages extending around the entire circumference and above the tip of the foot.  $\times .825$ .
- Fig. 9. Ventral view of the head.  $\times .825$ .
- Fig. 10. Detail of retracted right rhinophore stalk, looking down directly upon the retracted plumes which surround it.  $\times 1.5$ .







## PLATE 40

Fig. 1. *Dendronotus albus* MacFarland, new species

(Pages 275-279)

- Fig. 1. Painting made from living specimen 29 mm. in length. The integument is most delicate, translucent, and of a faintly gray color. The terminal branches of the cerata, and the velar and rhinophore sheath processes are all a clear pure white. Such nudibranchs are difficult to represent as the shadow color must model the form, leaving the general color clear and bright. This is the most lovely of the three new species described.  $\times 5.6$ .

Fig. 2. *Dendronotus venustus* MacFarland, new species

(Pages 271-275)

- Fig. 2. This specimen, 20 mm. long, is represented as crawling over the stems of a red alga, to convey an impression of the thin, soft, foot margin. The pale green of the liver branches and the many spots of green and yellow are constant, while the series of encrusted white spots on the dorsum are most pronounced on the larger specimens. Painting by Anna B. Nash.  $\times 7.9$ .

Fig. 3. *Dendronotus subramosus* MacFarland, new species

(Pages 265-270)

- Fig. 3. The figure represents a study in varying shades of tan and brown; specimen 24 mm. in length. This species is found in a wide range of coloring from a pale yellow, deepened to orange, and red to a dark red-brown. Painting by Anna B. Nash.  $\times 6.5$ .

1



2



3



## PLATE 41

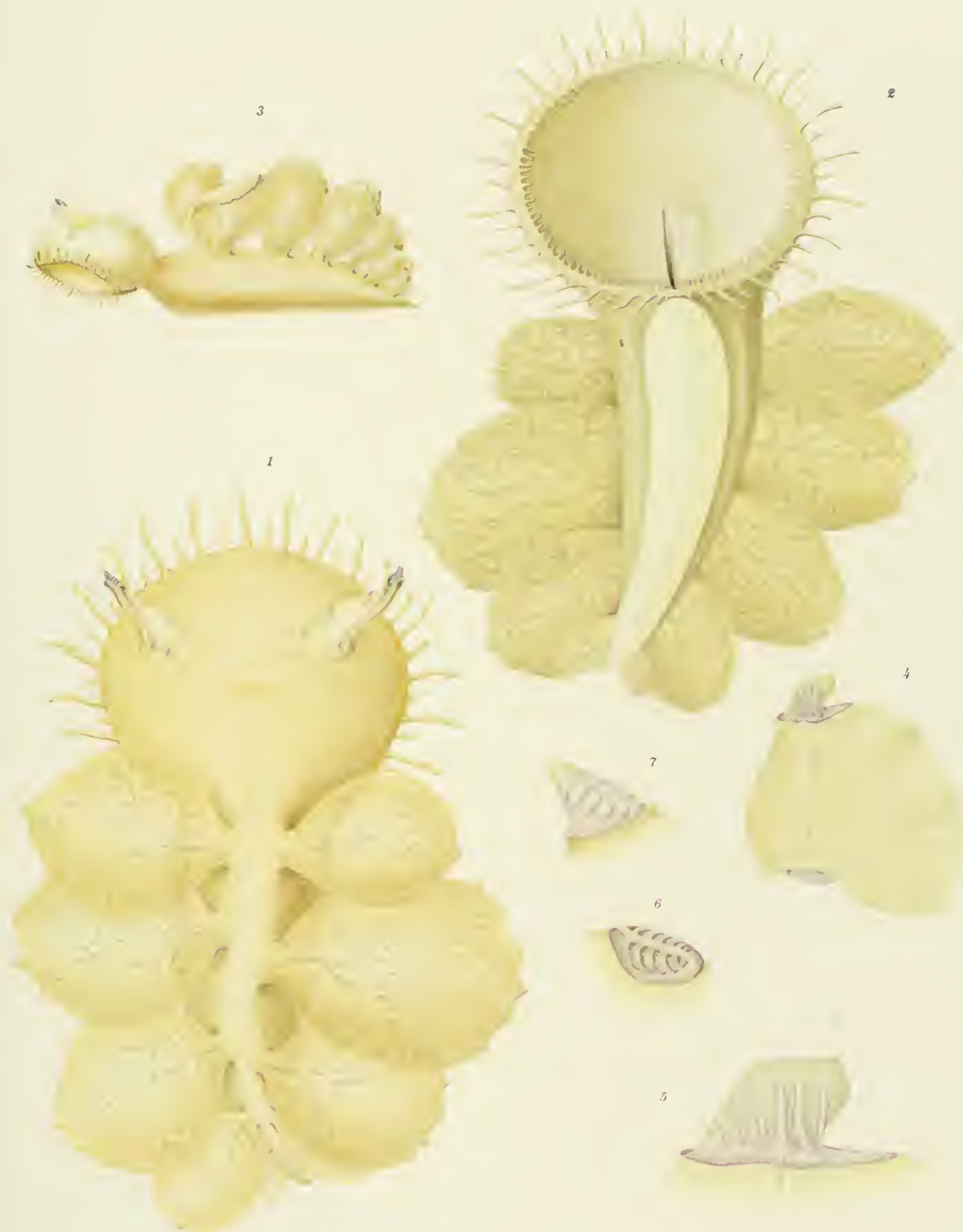
Figs. 1-7. *Chioraera leonina* Gould  
(Pages 280-287)

- Fig. 1. Dorsal view of live specimen taken from Monterey Bay.  $\times 4.8$ .  
Fig. 2. Ventral view made from the same specimen.  $\times 4.8$ .

These two figures show the great delicacy and transparency of this unusual animal. The intricate network of the liver branches is well represented. The shade of the yellow color varies slightly under different conditions; lemon yellow, modified, was used in these figures. The radiating muscle fibers, visible on the ventral side of the ceras, are not shown.

- Fig. 3. The figure represents a side view; drawing made from sketches of a living animal.  $\times 2.4$ .  
Fig. 4. A series of camera-lucida drawings was made of the distal end of the rhinophore, using a large alcoholic specimen from Alaska. Here is shown a general view of the rhinophore and wing. Plates on the flattened face of the clavus are shown in their proportional relation to the other parts.  $\times 5.6$ .  
Fig. 5. An enlargement of the same drawing shows in detail the tip of the clavus and plates on one side. The nerve, with its ganglion, which innervates the tip, is depicted.  $\times 16$ .  
Fig. 6. An oblique view from above of the rhinophore clavus, so inclined that the plates on both sides of the median ridge are in view.  $\times 9.6$ .  
Fig. 7. A slightly different view of the clavus, seen here in profile from above.  $\times 9.6$ .

The rhinophore sheath is elliptical; above it the stalk arises as the perfoliate clavus, retractile within the sheath. The laminae of the clavus, five or six in number, are borne upon either side of the flattened face. The obliquely set plates arise from a central ridge-like portion which projects above in a blunt point.



## PLATE 42

Figs. 1-8. **Doto varians** MacFarland, new species

(Pages 289-295)

- Fig. 1. Drawing from life. Yellow specimen feeding upon the hydroid *Abietinaria* in a realistic pose. Tubercles arranged in circles about a slender stalk; these terminating about a large one at the apex. On the inner side of the stalk these circles are broken by colorless ridges, containing vascular channels, which arise from the base extending upward with branches, gill-like modifications. Specimen  $\times 7$ ; hydroid  $\times 20$ .
- Fig. 2. The figure shows a dorsal view of a specimen 10 mm. in length. This belongs to a variety which is definitely marked on the surface by lines and spots of light to deep brown; two parallel lines are found upon the dorsum, carried over the sides between the cerata, terminating at the foot line. Painting by Anna B. Nash.  $\times 14$ .
- Fig. 3. Drawing of the ventral side of a variety entirely yellow in color, the foot pale, the egg mass orange. The cerata, thrown to the side, show the tubercles to advantage, the liver branches a light brown.  $\times 11.4$ .
- Fig. 4. Profile view of specimen showing the brown surface markings; as often occurs, the cerata are more slender with smaller tubercles. This is also characteristic of the very pale specimen with no markings.
- Fig. 5. Outside of ceras of a yellow specimen, tubercles frosted with white.  $\times 12$ .
- Fig. 6. Inside of third cerata to the left, showing the gill-like vascular ridges.  $\times 12$ .
- Fig. 7. Liver coloring rose, rare; area above ridge free from tubercles.  $\times 10$ .
- Fig. 8. A striking ceras from a dark-spotted specimen, seen in profile. The inner flange strongly developed, its upper, projecting, blunted tip a free flattened lobe, clear and transparent. Nodular branches arise from the main stalk.  $\times 8$ .





## PLATE 43

A. Figs. 1-9. *Duvaucelia tetraquetra* (Pallas)

(Pages 208-218)

- Fig. 1. Mandibles seen from above in normal position with convex surface up, showing the overlap of the right over the left mandible above the ligament.  $\times 2.33$ .  
Fig. 2. View of both mandibles seen obliquely from front and side.  $\times 2.33$ .  
Fig. 3. Small area from the used part of the masticatory process; pavement-like surface formed by the ends of chitinous prisms, arranged in irregular rows.  $\times 350$ .  
Fig. 4. Figure made of the youngest zone from the lowest part of the free process of the masticatory margin.  $\times 350$ .  
Fig. 5. Median tooth and first lateral from the radula, 43rd row, seen from above.  $\times 100$ .  
Fig. 6. First lateral, oblique view from the side.  $\times 100$ .  
Fig. 7. Two laterals near the center of radula, side view showing base.  $\times 100$ .  
Fig. 8. Thirty-seventh tooth in profile, showing the denticle on the anterior margin and the outline of the base.  $\times 100$ .  
Fig. 9. Four outermost teeth of the 40th row.  $\times 100$ .

B. Figs. 10-19. *Duvaucelia festiva* (Stearns)

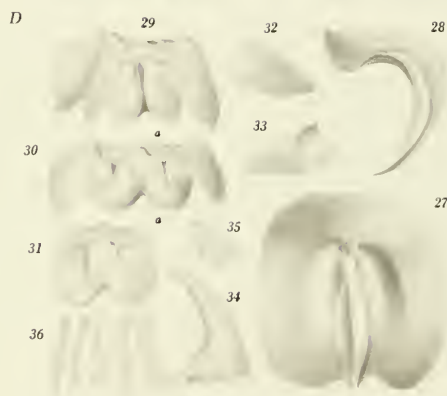
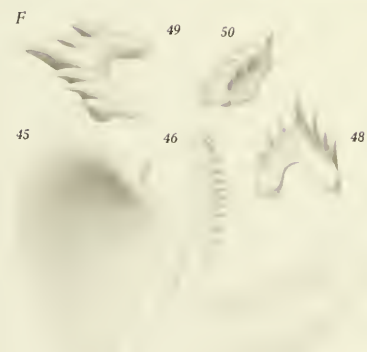
(Pages 218-226)

- Fig. 10. Mandibles in position as seen from above, slightly oblique view; upper surface very convex; masticatory margin, younger portion, short.  $\times 6.7$ .  
Fig. 11. Armature of the masticatory margin highly magnified.  $\times 215$ .  
Fig. 12. Drawing made from serial sections; this shows the tip of the masticatory margin developing armature; each rodlet caps a large single cell, a thin cuticle overlies these, developed by the cells above.  $\times 106$ .  
Fig. 13. Median tooth from seventh row with first lateral on either side, showing the small denticles on the anterior border.  $\times 104$ .  
Fig. 14. Same teeth seen from the ventral side, base rectangular.  $\times 104$ .  
Fig. 15. Median tooth from the front and below.  $\times 104$ .  
Fig. 16. Second lateral tooth shows hook and outline of base.  $\times 100$ .  
Fig. 17. Fortieth lateral tooth, increased in size but same form.  $\times 100$ .  
Fig. 18. An outer lateral much decreased in size.  $\times 100$ .  
Fig. 19. Otoliths, about 20 to 24 in all.  $\times 218$ .

C. Figs. 20-26. *Duvaucelia exsulans* (Bergh)

(Pages 226-235)

- Fig. 20. United mandibles in relative normal position; concavity at the base of the reflected masticatory margin along the posterior half.  $\times 4$ .  
Fig. 21. Profile view of single mandible; actual length, in a straight line, 11.4 mm.  $\times 4$ .  
Fig. 22. One-half of mandible tip cut through the ligament.  $\times 4$ .  
Fig. 23. Masticatory margin at the base of the process, uninjured portion, shows four oblique rows of conical denticles.  $\times 168$ .  
Fig. 24. Median tooth of radula, 22nd row, inner margin of first laterals overlapping the outer portion of the median tooth. This margin is thin and transparent.  $\times 64$ .  
Fig. 25. Second lateral with compressed elongated hook.  $\times 64$ .  
Fig. 26. Thirty-third lateral of the 34th row, height increasing, outline of base in view.  $\times 64$ .





D. Figs. 27-36. *Duvaucelia gilberti* MacFarland, new species

(Pages 235-243)

- Fig. 27. Mandibles in normal position; masticatory margin reflected, short, and much worn but entirely smooth.  $\times 25$ .  
Fig. 28. Mandibles cut through the hinge showing it to be long and narrow, the anterior lateral surface quite concave.  $\times 25$ .  
Fig. 29. Median tooth from oldest part of radula, first and second laterals on the right, first on the left; central cusp of median tooth cleft into two pyramidal points.  $\times 51$ .  
Fig. 30. Median tooth and first laterals, 25th row; median with deep notch on anterior margin, deep lateral groove on either side of median cusp, *a* to *a*.  $\times 51$ .  
Fig. 31. Single median showing lateral cusp merged with the central one.  $\times 51$ .  
Fig. 32. First lateral, innerface, somewhat pyramidal in shape with hook-like apex.  $\times 51$ .  
Fig. 33. Drawing shows median tooth cut through *a-a* in figure 30.  $\times 51$ .  
Fig. 34. Lateral from the middle of the 40th row showing hook at full height, base visible.  $\times 51$ .  
Fig. 35. Outermost laterals from 45th row, slender and oblique.  $\times 51$ .  
Fig. 36. Ventral surfaces of first five lateral teeth.  $\times 51$ .

E. Figs. 37-44. *Armina californica* (Cooper)

(Pages 198-206)

- Fig. 37. United mandibles, tip of masticatory margin long.  $\times 6$ .  
Fig. 38. Mandibles separated along the line of the masticatory margin and hinge of right mandible; this region slightly crescentic.  $\times 6$ .  
Fig. 39. Armature of the mandibular process; low flattened plates.  $\times 135$ .  
Fig. 40. Median tooth of radula with three laterals; wide broad base with a deep groove on the anterior margin, median cusp with two lateral denticles arising from the basal portion, lateral to these are three to five stout denticles. Second and third laterals show the spur-like process projecting inward and forward from the base.  $\times 128$ .  
Fig. 41. First lateral with a square broad base and stout hook inclined toward the median line, inner and outer wing-like projections from the base.  $\times 128$ .  
Fig. 42. Large lateral showing the slender denticle on the outer margin, spur from the base not visible.  $\times 128$ .  
Fig. 43. Laterals showing the variation in the forking of the denticles.  $\times 128$ .  
Fig. 44. Four outermost teeth.  $\times 128$ .

F. Figs. 45-50. *Hancockia californica* MacFarland

(Pages 246-254)

- Fig. 45. Mandible showing inner surface, very thin and delicate except thickened at the hinge region, deeply concave below, this becoming flattened as the margin is reached.  $\times 62$ .  
Fig. 46. Tip of masticatory process with 20 to 30 blunt denticles appearing to be in more than a single series, membranous tissue extending below.  $\times 310$ .  
Fig. 47. Median tooth and two laterals from the 20th or 21st rows, view from above, median massive, laterals thin, transparent.  $\times 310$ .  
Fig. 48. Ventral view of median tooth.  $\times 310$ .  
Fig. 49. Single median tooth, oblique view.  $\times 310$ .  
Fig. 50. Fully developed median as seen in side view.  $\times 310$ .

## PLATE 44

Fig. 1. *Duvaucelia tetraquetra* (Pallas)

(Pages 208-218)

- Fig. 1. Reproductive system as seen from above, the parts in their natural relations; the genital complex is small in comparison with the size of the specimen. The surface shows irregular windings of the *m. gl.*, mucous gland; *h. amp.*, hermaphroditic ampulla lies in a series of convolutions at the posterior end; *gl. p.*, glans penis is large, conical, unarmed organ; *vag.*, vagina at its proximal end, terminates in the blind sac, the *sph.*, spermatheca; the opening of genital glands is seen in the vagina near its opening into the vestibules.  $\times 2.4$ .

Fig. 2. *Duvaucelia festiva* (Stearns)

(Pages 218-226)

- Fig. 2. Figure of the reproductive system, parts slightly separated; muscular segment of the vas deferens probable prostatic in function; *gl. p.*, glans penis urn shaped, length and width being about equal; the margin of its broad flattened end has a row of minute papillae not shown in the drawing; the external opening, in its center, is concealed under a thickened pointed flap; *vag.*, vagina is a rounded tube terminating in a long slender duct leading into the *sph.*, spermatheca, a blind sac.  $\times 10$ .

Figs. 3, 4. *Duvaucelia exsulans* (Bergh)

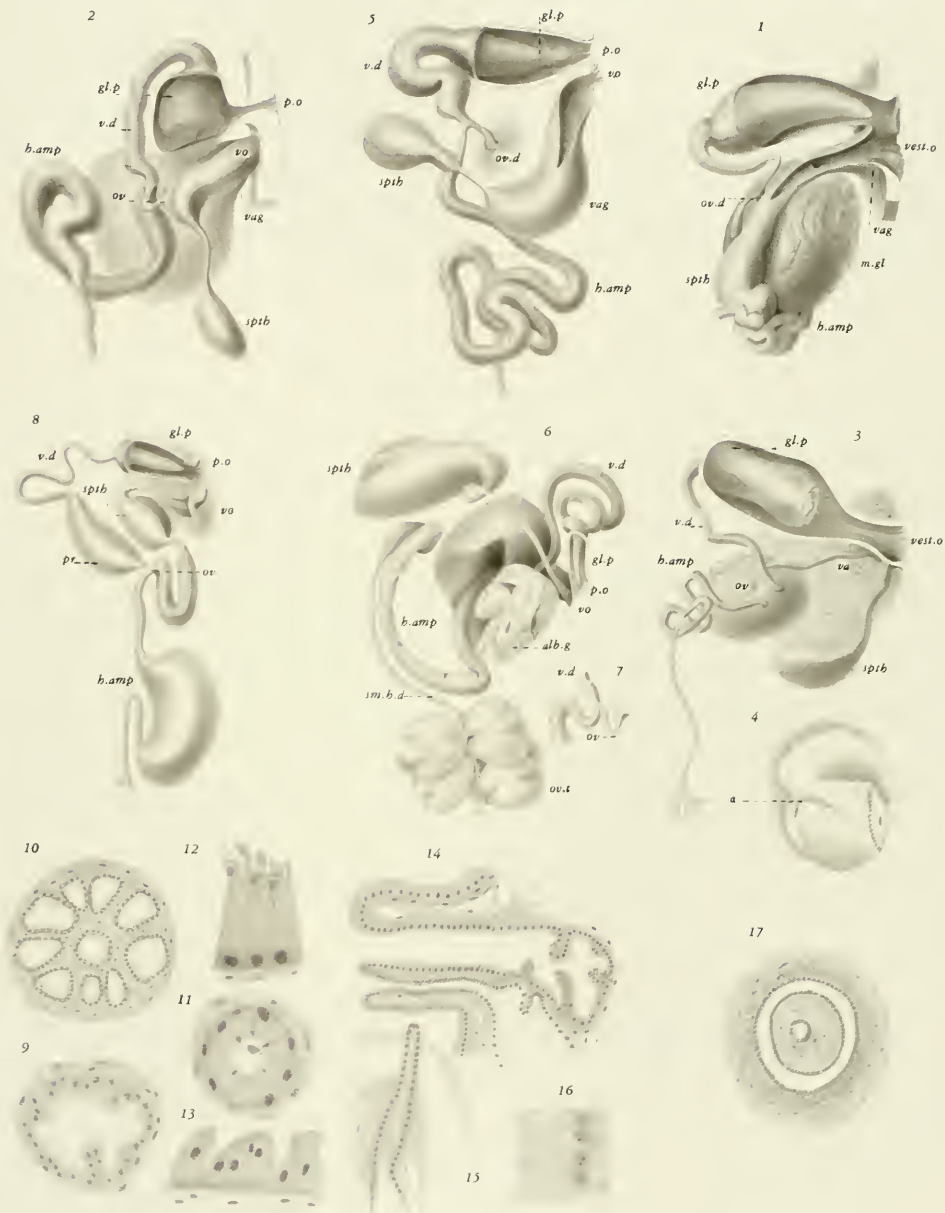
(Pages 226-235)

- Fig. 3. The drawing shows the reproductive complex with the parts somewhat separated; hermaphroditic duct and *h. amp.*, ampulla both very slender; the *gl. p.*, glans penis is an elongated rounded mass, a ridge encircles the area at its extremity, armed with a series of thorn-like spines; vagina and its blind sac as in the other *Duvaucelia* species; openings converge into the genital vestibule.  $\times 8$ .
- Fig. 4. Detail of the glans penis from a dissection of an alcoholic specimen, armature of thorn-like spines on the ridge bounding the truncate end, a groove runs lengthwise upon the surface at *a*.  $\times 15$ .

Fig. 5. *Duvaucelia gilberti* MacFarland, new species

(Pages 235-243)

- Fig. 5. Genital complex is similar, in its parts, to the other species of the genus. The glans penis, however, presents a form very different from the others. The glans which has a broad base tapers to 1 mm. in diameter when abruptly it widens into a narrow ring with concave sides and a sharp edge, again narrows, and terminates in a spherical knob 2 mm. in diameter; on the distal surface is the external opening of the vas deferens. No surface armature was found. This peculiar form was recognized in all specimen dissected.  $\times 2.5$ .







Figs. 6, 7. *Armina californica* (Cooper)

(Pages 198-206)

- Fig. 6. Reproductive complex with parts relatively in natural position, but separated for a clearer view; hermaphroditic ampulla, *h. amp.*, long and saccular, entering the gland mass in a depression where the spermatheca, *sph.*, rested, the branchings of the oviduct and vas deferens are hidden; the latter dilates into the thicker segment, closely looped upon itself before entering the preputium; the small pointed glans penis, *gl. p.*, opens above the small vagina opening, *v. o.*, into the genital vestibule.  $\times 4$ .
- Fig. 7. Detailed drawing to show the branching of the hermaphroditic ampulla into the vas deferens and oviduct; the latter entering the nidamental gland at once, the vas deferens emerging in a series of loops; the albumen gland is conspicuous as a series of white winding loops.  $\times 4$ .

Figs. 8-17. *Doto varians* MacFarland, new species

(Pages 289-295)

- Fig. 8. Anterior genital complex. The dissection was used but serial sections were most necessary as the complex is quite small; the hermaphroditic ampulla is comparatively large; its distal duct dividing into the vas deferens and oviduct; the former at once enlarges into the prostatic segment, this sac-like portion narrows into the duct entering the preputium and glans penis leading to the external opening. The female vestibulum lies just behind the male opening. The oviduct emerges very narrow from the spermatheca (receptaculum seminis) and dilates at once into a relatively wide channel forming a U-shaped loop. At the anterior end it unites with the distal end of the hermaphroditic duct as this gives off the vas deferens.  $\times 24$ .
- Fig. 9. Transverse section of the vaginal duct near the apex of the receptaculum seminis; the duct at this point shows radial folds in its wall with ciliated epithelium; these folds extend toward the center of the sac and join an inner prolongation of a narrow duct entering the sac near its widest portion.  $\times 212$ .
- Fig. 10. Transverse section of the spermatheca in its proximal region. The central prolongation of the oviduct is surrounded by the sac-like diverticula which open into it distally, and which are usually filled with sperm. A wheel-like appearance is thus formed, as shown in the figure; the axis or hub being formed by the invaginated duct which communicates freely with the lumen. The whole to be interpreted as a modified receptaculum seminis.  $\times 135$ .
- Fig. 11. Transverse section of the vas deferens beyond its prostatic segment, cells filled in the distal portion with fine granules, basal nuclei large and dark; single rod-like inclusions occur between the cells, the distal ends of these triangular and ciliated.  $\times 212$ .
- Fig. 12. Wall of the distal end of the prostate near the opening into the vas deferens; secretion droplets from the granular cells; cilia from the included cells.  $\times 386$ .
- Fig. 13. Wall of the prostate showing inner epithelial folds and varying heights of prostatic epithelium.  $\times 212$ .
- Fig. 14. Longitudinal section of the anal papilla showing anal and renal openings and the distal end of the kidney sac.  $\times 135$ .
- Fig. 15. Longitudinal section of the renal syrinx opening from the pericardium at the left.  $\times 135$ .
- Fig. 16. Renal epithelium.  $\times 650$ .
- Fig. 17. Cross section of glans penis and preputium, vas deferens duct through the center. Diameter of glans .115 mm., diameter of preputium inside .13 mm., outside .24 mm. Longitudinal muscle fibers lie close outside the cubical epithelium of the preputium and under the outer epithelium of the glans.  $\times 135$ .

## PLATE 45

Figs. 1-5. *Duvaucelia tetraquetra* (Pallas)

(Pages 208-218)

- Fig. 1. Camera-lucida drawing from a mount of the central nervous system. The cerebral and pleural ganglia form an elongated mass. The spherical pedal ganglia are united to the cerebral and pleural by distinct connectives. The pedal, parapedal, and sub-cerebral commissures all loop below the oesophagus. The buccal complex, with nerves, lies below, united with the cerebral ganglia by a long slender connective.  $\times 14$ .
- Fig. 2. Transverse section through the pyloric girdle, *m*, circular muscle layer; *p*, sub-epithelial stratum of connective tissue; *e*, gastric epithelium thrown into numerous ridges which are capped by strong cuticular thickenings, *c*.  $\times 12$ .
- Fig. 3. Inner surface of gastric girdle; width of girdle 10.5 mm.; folds, or ridges, extending the full width; 12 to 15 such folds.  $\times 2.5$ .
- Fig. 4. Transverse section through one gastric ridge; muscular layer, connective tissue, gastric epithelium and cuticle as in figure 2, under higher magnification.  $\times 32$ .
- Fig. 5. Anterior salivary gland.  $\times 4$ .

Fig. 6. *Duvaucelia gilberti* MacFarland, new species

(Pages 235-243)

- Fig. 6. The cerebro-pleural ganglia are closely fused; the cerebral moiety somewhat crescentic, pleural ganglia rounded. The pedal ganglia, which are comparatively large, have relatively long connectives with the cerebral and pleural ganglia. These are united in a common epineural sheath, only distinguishable in sections. The cerebral buccal connective arises from the ventral side of the cerebral ganglia; the buccal complex as in figure 1.  $\times 6.75$ .

Figs. 7, 8. *Duvaucelia festiva* (Stearns)

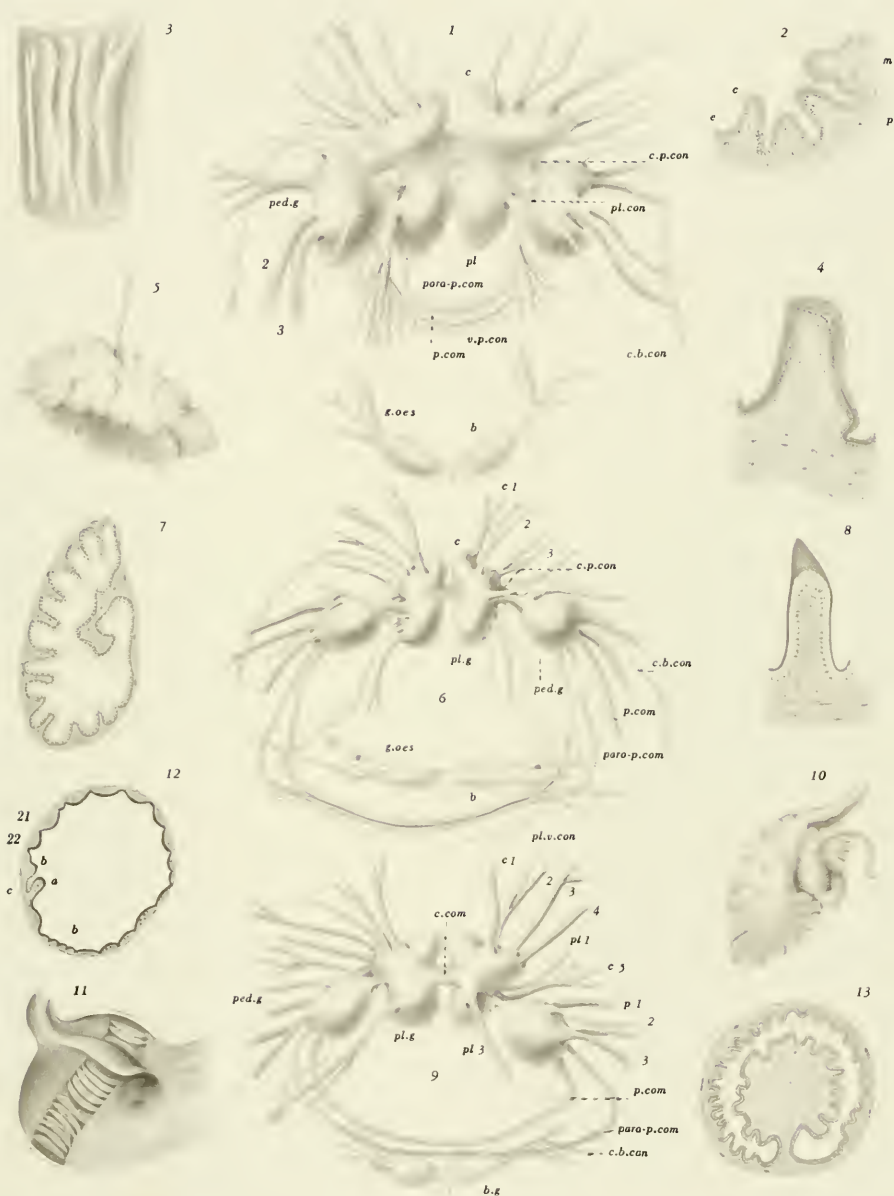
(Pages 218-226)

- Fig. 7. Drawing of cross section of the intestine; the typhlosole extends far into the lumen and continues along the intestine for about half its length, numerous smaller folds are found throughout its extent.  $\times 45$ .
- Fig. 8. Transverse section through a single ridge from the gastric girdle which is 4 mm. in width, with 18 to 20 folds. The cuticle, thick on the crest, thins away over the grooves between the ridges.  $\times 30$ .

Figs. 9-13. *Duvaucelia exsulans* (Bergh)

(Pages 226-235)

- Fig. 9. The figure is a camera-lucida drawing made from a mount of a Monterey Bay specimen. The cerebral ganglia are reniform in contour, united broadly with the pleural ganglia. The cerebro-pedal and pleuro-pedal connectives are short and narrow. The pedal and parapedal commissures pass under the oesophagus; the buccal ganglia lie below. Stout nerves arise from the anterior cerebral and posterior pleural ganglia.  $\times 10$ .
- Fig. 10. Drawing made from a dissection showing the external surfaces of the oesophagus, stomach, the pyloric girdle, intestine, and liver, all in their normal relations.  $\times 15$ .
- Fig. 11. Inside of the pyloric region of the stomach, exposing the gastric girdle, 3 mm. wide, with about 15 plates; typhlosole extending across the zone, with the duct into the liver below.  $\times 2.5$ .





- Fig. 12. Cross section of the gastric girdle; when the circular muscular band is contracted, the plate-like ridges evidently become higher. In this figure, platelet 22, from midgroove to midgroove is 0.75 mm.; height of the same, crest to outer adventitia, 0.39 mm. The shortest and narrowest is platelet 6, with a width of 0.18 mm., height 0.24 mm. The widest platelet, 21, in section, is 0.945 mm. in width.
- Two of the ridges, *a* and *b*, are much higher than the remainder and extend entirely across the girdle, leading into the opening of the liver; merging posteriorly with the typhlosole folds of the intestine. The groove between these folds is lined with ciliated columnar epithelium, forming an open channel for the passage of the liver secretions into the intestine.  $\times 4$ .
- Fig. 13. Transverse section of the intestine through the large typhlosole extending into its lumen which is 1.6 mm. in diameter.  $\times 16$ .



## PLATE 46

Figs. 1-4. **Dendronotus albus** MacFarland, new species

(Pages 275-279)

- Fig. 1. Twenty-fourth row of the radula; lateral teeth of two rows; median tooth with small rounded denticles; laterals thin and flat, the innermost elevated somewhat.  $\times 290$ .  
Fig. 2. Ventral view of two median teeth; thick oval base, anterior margin with rounded lateral extensions.  $\times 290$ .  
Fig. 3. Median teeth seen obliquely.  $\times 290$ .  
Fig. 4. First two oldest median teeth, small and worn.  $\times 290$ .

Figs. 5-8. **Dendronotus subramosus** MacFarland, new species

(Pages 265-270)

- Fig. 5. Nineteenth and 20th rows; median and seven lateral teeth; posterior margin of median with pointed overlapping denticles; anterior margin with long lateral extensions.  $\times 398$ .  
Fig. 6. Oblique view of three median teeth at the angle of the radula, 26th, 27th, 28th.  $\times 580$ .  
Fig. 7. Ventral view, from above, of median tooth showing wide pointed extensions of the base.  $\times 530$ .  
Fig. 8. First and second oldest median teeth, greatly reduced in size.  $\times 488$ .

Figs. 9-12. **Dendronotus venustus** MacFarland, new species

(Pages 271-275)

- Fig. 9. Twenty-second and 23rd rows counting from the oldest; median teeth with large strong cusps bearing long pointed denticles; laterals with pointed cusps elevated and curved toward the center, denticles low.  $\times 458$ .  
Fig. 10. Ventral view of median teeth of older rows; base narrow, wide extension of anterior margin.  $\times 458$ .  
Fig. 11. First and second oldest median teeth, seen obliquely from above.  $\times 458$ .  
Fig. 12. Profile of median tooth seen obliquely from the front, showing the curve under the cusp and the base.  $\times 458$ .



## PLATE 47

Figs. 1, 2. *Dendronotus venustus* MacFarland, new species

(Pages 271-275)

- Fig. 1. Inner face of right mandible, the concave inner face bearing a long, strong, grooved prolongation.  $\times 70.6$ .  
Fig. 2. Lowermost section of the masticatory margin, teeth curved backward and bearing ridge-like denticles, the outer surfaces of the younger and larger ones roughened with minute spines.  $\times 604$ .

Figs. 3-7. *Dendronotus subramosus* MacFarland, new species

(Pages 265-270)

- Fig. 3. Inner face of right mandible.  $\times 26$ .  
Fig. 4. Enlarged detail of mandible hinge and the inner edge of the mandibular process.  $\times 197$ .  
Fig. 5. Detail of denticles on the masticatory inner margin, upper one-third, near the hinge.  $\times 604$ .  
Fig. 6. Detail of denticles near the center of the process; close, transverse, crescentic plates.  $\times 604$ .  
Fig. 7. Detail of four denticles near the tip as seen from without; points curved over the edge of the process.  $\times 604$ .

Figs. 8-11. *Dendronotus albus* MacFarland, new species

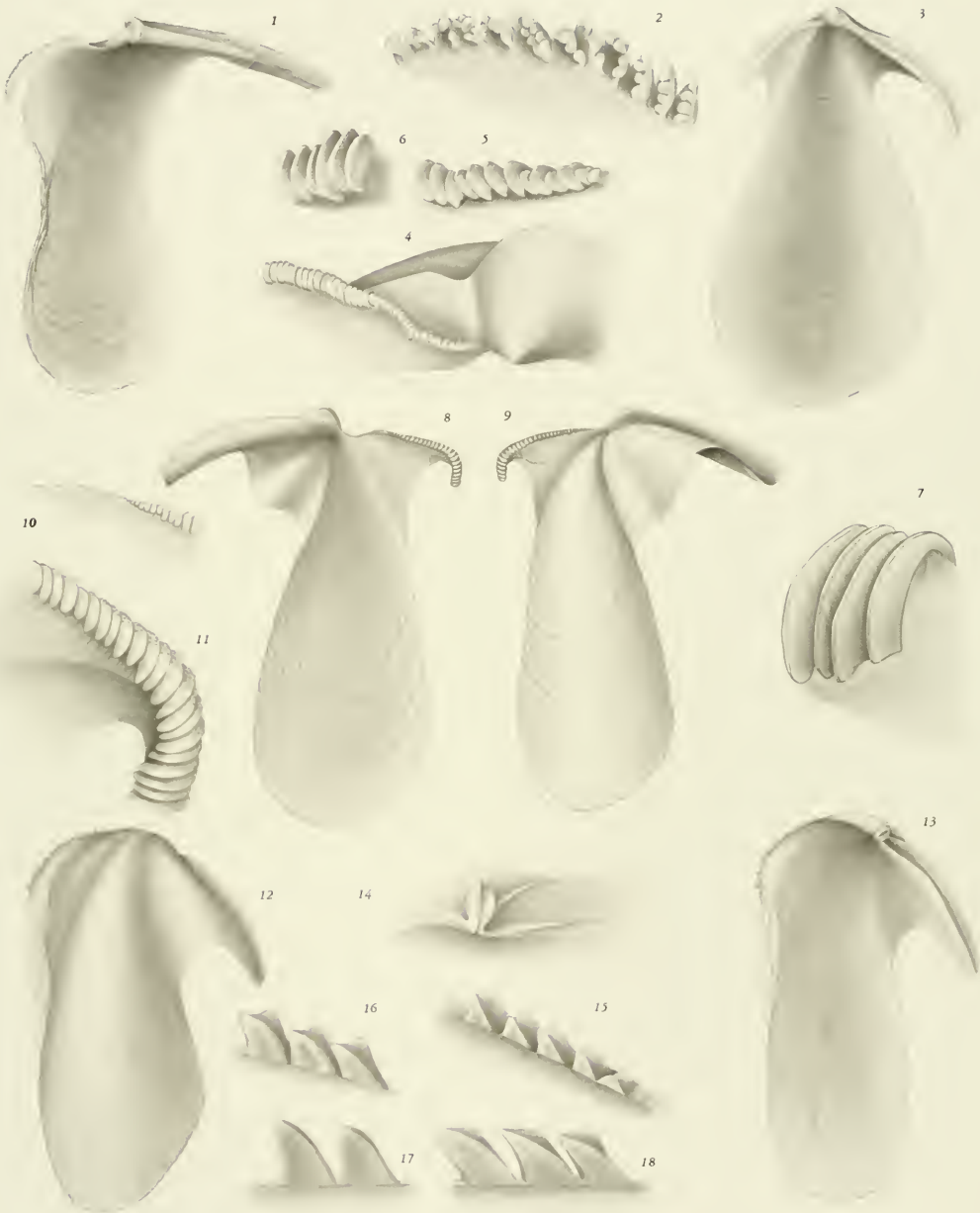
(Pages 275-279)

- Fig. 8. Inner face of left mandible.  $\times 34.4$ .  
Fig. 9. Outer face of same mandible. Double mandibles figured elsewhere.  $\times 34.4$ .  
Fig. 10. Inner edge, top of masticatory margin next to the hinge.  $\times 218$ .  
Fig. 11. Inner edge, left mandible, lower third showing large denticles at the tip curved inward.  $\times 218$ .

Figs. 12-18. *Dendronotus iris* Cooper

(Pages 257-265)

- Fig. 12. Outer face of left mandible.  $\times 4.2$ .  
Fig. 13. Inner face of right mandible.  $\times 4.2$ .  
Fig. 14. Detail of right hinge, inner face.  $\times 12.4$ .  
Fig. 15. Uppermost denticles of the masticatory margin, at the hinge, seen obliquely.  $\times 197$ .  
Fig. 16. Three denticles seen obliquely, showing the increase in size.  $\times 197$ .  
Fig. 17. Front view of two denticles near the center of the margin.  $\times 197$ .  
Fig. 18. Three large denticles at the tip of the process, slightly oblique view showing the point of the top on the opposite side.  $\times 197$ .



## PLATE 48

Figs. 1-6. *Dendronotus iris* Cooper

(Pages 257-265)

- Fig. 1. Two successive rows from the radula; median teeth with four adjacent laterals on the right, three on the left. Median bears strongly developed pointed denticles on the oblique side of the large cusp, laterals usually with smooth cusps.  $\times 180$ .
- Fig. 2. Oldest median as seen from above.  $\times 180$ .
- Fig. 3. Median in lateral view, showing throat and base.  $\times 180$ .
- Fig. 4. Oblique view of median with inclination of cusp, lateral denticles, shape of base, all shown.  $\times 180$ .
- Fig. 5. Ventral view of median tooth.  $\times 180$ .
- Fig. 6. Rhinophore measurements taken from a well preserved alcoholic specimen 85 mm. in length. The stout stalk terminates in the sheath of the retractile clavus which is prolonged by widespreading, arborescent processes. A series is also arranged in a vertical row down the posterior face of the stalk. These are of constant occurrence and form a ready means of identification.  $\times 3$ .

Figs. 7, 8. *Dendronotus albus* MacFarland, new species

(Pages 275-279)

- Fig. 7. Outer face of both mandibles in normal relation of parts; high flaring wings with strongly recurved margins dying away at the hinge, and thin cuticular lining bridging the space above the hinge are represented in the upper section of the figure. Below, a pointed triangular groove, at the lower margin of the oral cavity, is formed by the cuticular membrane, slightly thickened laterally into a narrow elongated plate; the posterior portion thins away. The masticatory process is short, its ventral tip curved sharply backward, bearing an armature of 70 to 80 transverse plate-like ridges.  $\times 213$ .
- Fig. 8. Composite drawing of the inner face of the mandibles in normal position; the lining of cuticular membrane continued to a point below the masticatory tips, elsewhere cut away.  $\times 22.6$ .

Figs. 9-13. *Doto varians* MacFarland, new species

(Pages 289-295)

- Fig. 9. Mandibles in position, triangular and shell-like, thickened at the hinge; no mandibular process or armature can be seen.  $\times 110$ .
- Fig. 10. Dorsal view of median tooth from the radula of a doto of yellow colorings, most frequently found in Monterey Bay.  $\times 880$ .
- Fig. 11. Ventral view of median from the same radula; median posterior cusp depressed below a triangular denticle of equal size, on either side close to this center cusp.  $\times 880$ .
- Fig. 12. Smaller median tooth from radula of specimen of dark coloring.  $\times 880$ .
- Fig. 13. Dorsal view from the same radula to show variation in denticles.  $\times 880$ .





## PLATE 49

Figs. 1-3. **Dendronotus subramosus** MacFarland, new species

(Pages 265-270)

- Fig. 1. Central nervous system, seen from the side; cerebral and pleural ganglia, nearly equal in size, are fused; pedal ganglia united by a short commissure; optic ganglia clearly seen; buccal ovoid, connected with cerebral by a short connective.  $\times 28$ .  
Fig. 2. Central nervous system in dorsal view.  $\times 28$ .  
Fig. 3. Ventral view of head, anterior margin rounded, processes stout and short.  $\times 5.7$ .

Fig. 4. **Dendronotus iris** Cooper

(Pages 257-265)

- Fig. 4. Ventral view of head; a composite drawing from several preserved specimens; the frontal veil is obscure but marked by six to eight large branched processes, the innermost two the largest. Between this row of large processes are three or more irregular transverse rows of simple or branched appendages.  $\times 1.9$ .

Fig. 5. **Dendronotus albus** MacFarland, new species

(Pages 275-279)

- Fig. 5. Ventral view of head; low oval velar margin bearing four long processes having branches from base to tip; inferior and in advance of this series, toward the lip-disk, are shorter appendages of varying number.  $\times 6.6$ .

Fig. 6. **Dendronotus venustus** MacFarland, new species

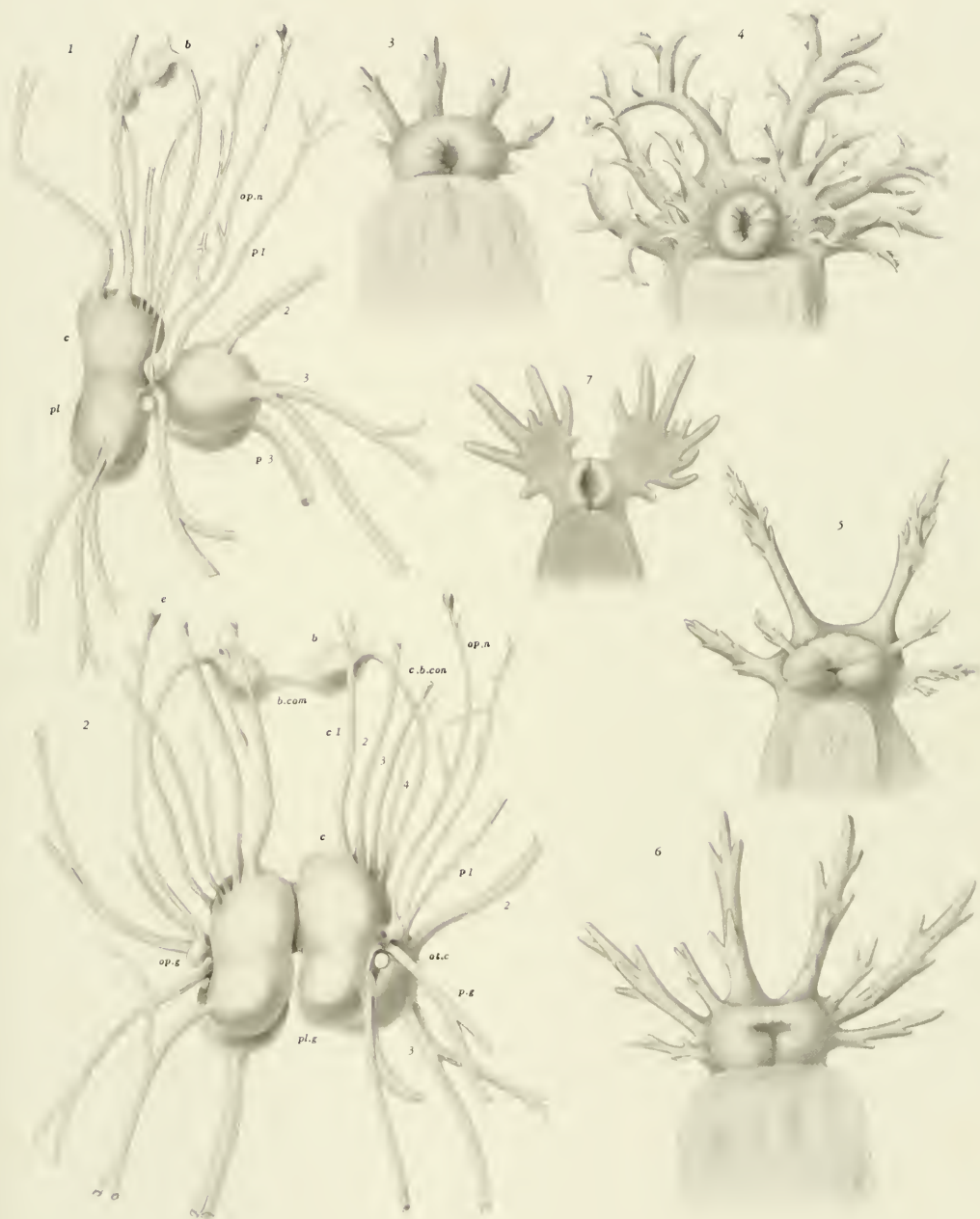
(Pages 271-275)

- Fig. 6. Head in ventral view; frontal veil well defined, having four to eight processes, four large constant ones, between these may occur smaller processes at a lower level.  $\times 6.6$ .

Fig. 7. **Hancockia californica** MacFarland

(Pages 246-254)

- Fig. 7. Ventral view of head region; mouth a longitudinal slit, lips thickened; palmate velar processes are asymmetrical as regards digitations, the fundamental similarity is evident.  $\times 8$ .



## PLATE 50

Fig. 1. **Dendronotus iris** Cooper  
(Pages 257-265)

- Fig. 1. The figure represents the parts as somewhat displaced in order to make clear the relations; the large glands of the complex being omitted. *Dendronotus iris* is the largest of the four species described. The prostatic segment, being long, is made up of closely packed glandular alveoli, completely concealing the loops of the deferent canal; the vagina is large, as are the other parts, in comparison.  $\times 2$ .

"The great range, in the magnification used by the author in the following three figures, is an effort to make them comparable to *Dendronotus iris*." O. H. MacF.

Fig. 2. **Dendronotus subramosus** MacFarland, new species  
(Pages 265-270)

- Fig. 2. The vas deferens widens into the greatly enlarged prostatic portion, its proximal limit being marked by a closely crowded ring of alveolar glands; the large, thin-walled preputium incloses the long irregularly coiled and looped glans penis. This is one-third the length of the entire body.  $\times 14$ .

Fig. 3. **Dendronotus venustus** MacFarland, new species  
(Pages 271-275)

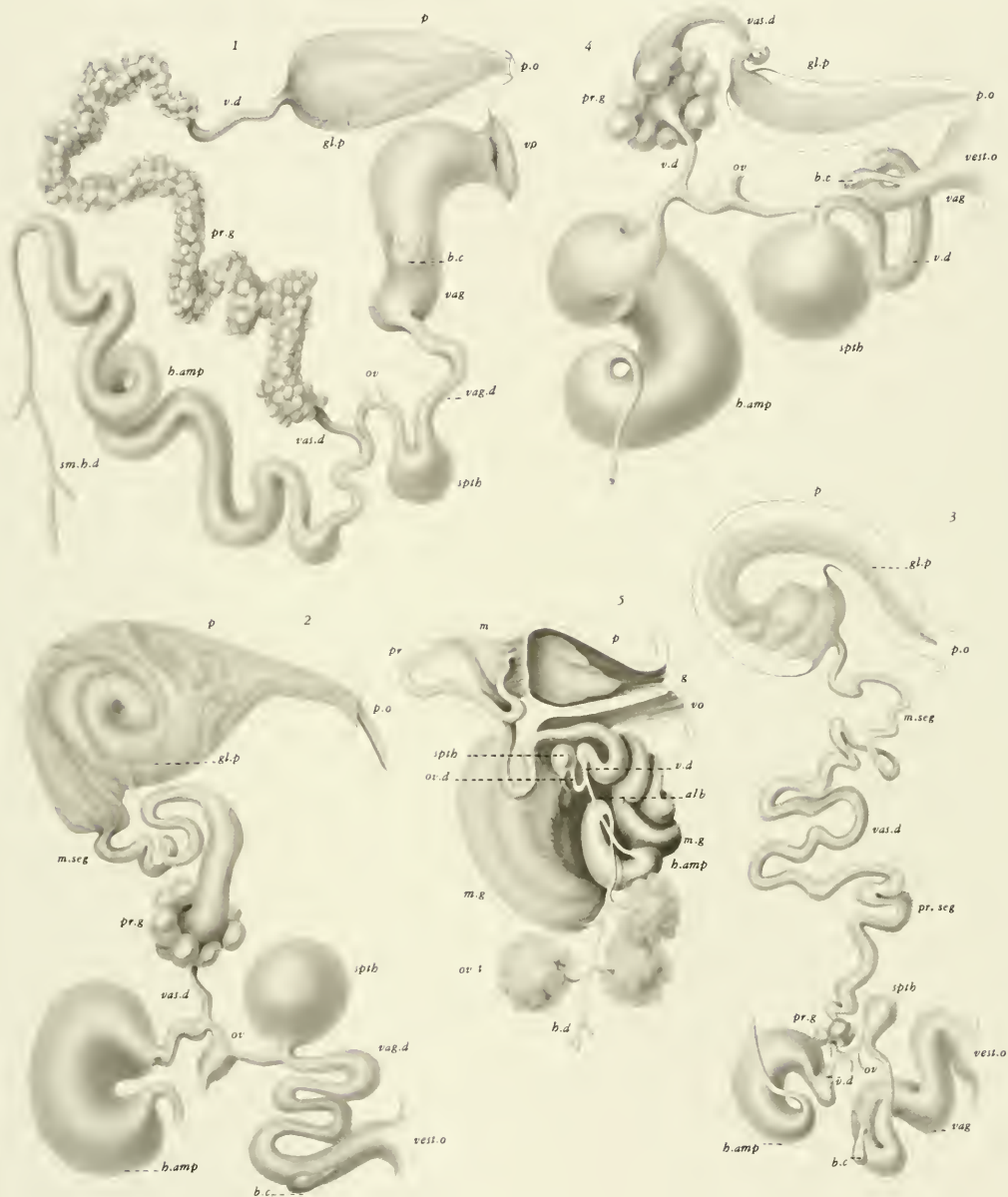
- Fig. 3. The ducts are in relatively true proportions, but separated. The glans penis is of irregular contour at its base, becoming straight as it is extended. The vagina is very large, opening into the vestibule and bearing a small bursa copulatrix, characteristic of all species described.  $\times 20$ .

Fig. 4. **Dendronotus albus** MacFarland, new species  
(Pages 275-279)

- Fig. 4. The ring of glandular alveoli on the dilated vas deferens is similar to that of *D. subramosus*, the glans shorter and straight, the ampulla large.  $\times 20$ .

Fig. 5. **Hancockia californica** MacFarland  
(Pages 246-254)

- Fig. 5. Reconstruction of the reproductive system, combined from serial sections in the three planes, and from dissections. Figure reproduced from MacFarland, The Morphology of the Nudi-branch Genus Hancockia, 1923 (pl. 6, fig. 22).  $\times 13$ .



## PLATE 51

Figs. 1-5. *Dendronotus iris* Cooper

(Pages 257-265)

- Fig. 1. Front view of pharyngeal bulb opening; oval opening external, lips convex, flesh, and glandular; muscular lips within these form the anterior end of the pharyngeal bulb, the outer margin of the inner opening shows the cuticle broken up into rodlets forming a collar.  $\times 3.5$ .
- Fig. 2. Labial armature; horizontal section showing the relations of the lip margins; inner lip, with its cuticle beginning at *a*, widening into a broad collar of rodlets at *b*, the anterior masticatory edge of the mandible above at *c*.  $\times 20$ .
- Fig. 3. Drawing from serial sections, showing a small portion of figure 2 under high magnification; an everted condition of the inner lip region in front view, concave face covered by cuticle which thickens and forms a prehensile ring at *b*, just in front of the masticatory process of the mandible at *c*. The rodlets are irregular and the collar formed is fine and fringe-like, each part corresponding to the epithelial cell at its base, with the nuclei close to the bottom of the cell.  $\times 180$ .
- Fig. 4. Epithelium in a narrow zone of radial folds immediately behind the zone of rodlets and very conspicuous on the inner face of the lip-disk; folds covered by a smooth cuticle.  $\times 60$ .
- Fig. 5. This figure shows these folds in a perspective reconstruction; the axes of the columnar cells, in the main, directed obliquely outward toward the free surface of the cuticle; the formation of these folds insures a greater number of rodlets being packed together in this immediate border area, at *b*.

Figs. 6, 7. *Dendronotus albus* MacFarland, new species

(Pages 275-279)

- Fig. 6. Front view of lip disk; mouth opening oval, posterior margin and sides smoothly rounded, upper anterior region indented by a longitudinal groove; inner circlet of rodlets shown but inner cuticle not plainly seen.  $\times 20$ .
- Fig. 7. Labial armature, horizontal section through one side of the inner opening; section shows the outer lip *a*, surface smoothly convex, which is closely beset with short tubular glands back to the dilatation in front of the inner lips. These are covered by a thick cuticle; above is a narrow cleft where the cuticle thins away; the central mouth region has the thickest cuticle at *b*, where it begins to break up into blunt flexible rodlets, reaching the longest, 0.3 mm., at the outer margin where a circlet is formed at *c*.  $\times 180$ .





## PLATE 52

Figs. 1, 2. **Dendronotus subramosus** MacFarland, new species  
(Pages 265-270)

- Fig. 1. Horizontal section through the lips and mandibles. The external lips are closely set with long tubular glands extending deep into the sub-epithelium. Convex mouth disks largely fill the external opening; thickest in the external region, but splitting up into a zone of long hair-like filaments on the outer margin.  $\times 48$ .
- Fig. 2. Zone of filaments under high magnification; bases of the long elements occupy a shallow groove, epithelial cells producing these lie under the cuticle of which they are a part.  $\times 312$ .

Figs. 3-6. **Dendronotus venustus** MacFarland, new species  
(Pages 271-275)

- Fig. 3. Labial disk; horizontal section, inner lip of one side of the mouth. The disk is covered by thin cuticle more delicate than in other species described; a longitudinal furrow is at the posterior margin, the surface is strongly arched, being differentiated into short blunt rodlets reduced to mere plates in the posterior region. Greatest development is reached on the lateral anterior face where the rodlets reach a length of .015 mm., forming a prehensile collar; outside of this, on the free surface, a length of .035 mm. is reached.  $\times 82$ .
- Fig. 4. Section from the stomach wall showing the ciliated epithelium.  $\times 135$ .
- Fig. 5. Section from the stomach wall showing the region of the gastric girdle, ciliated epithelium replaced by a thickened edge of cuticle above the epithelium.  $\times 135$ .
- Fig. 6. Outline drawing showing the external openings anal at *b*, and renal at *a*.  $\times 135$ .

Figs. 7, 7a. **Hancockia californica** MacFarland  
(Pages 246-254)

- Fig. 7. Diagram of reproductive system: *h. d.*, hermaphroditic duct; *h. amp.*, hermaphroditic ampulla; *v. d.*, vas deferens; enlarging at once into *pr.*, the prostate gland; *p.*, preputium cut open to show the glans penis, *gl. p.*; *ov.*, oviduct; *spth.*, the spermatheca; its duct leading into *f.*, the fertilization chamber, close to the entrance of *alb. gl.*, the albumen gland; *m.* and *m'*, the two divisions of the mucous gland; *vag.*, vagina, connected with the fertilization chamber by the vaginal duct, *vag. d.*
- Fig. 7a. Diagram of cross section of vaginal duct, incompletely divided by a longitudinal ridge into *c.*, the copulatory duct, and *ov.*, duct for oviposition. The copulatory channel leads into the spermatheca, while the lower egg-laying channel opens into the cavity of *m'*, the nidamental gland. MacFarland, The Morphology of the Nudibranch Genus *Hancockia*, 1923 (pl. 5, fig. 18a).



## PLATE 53

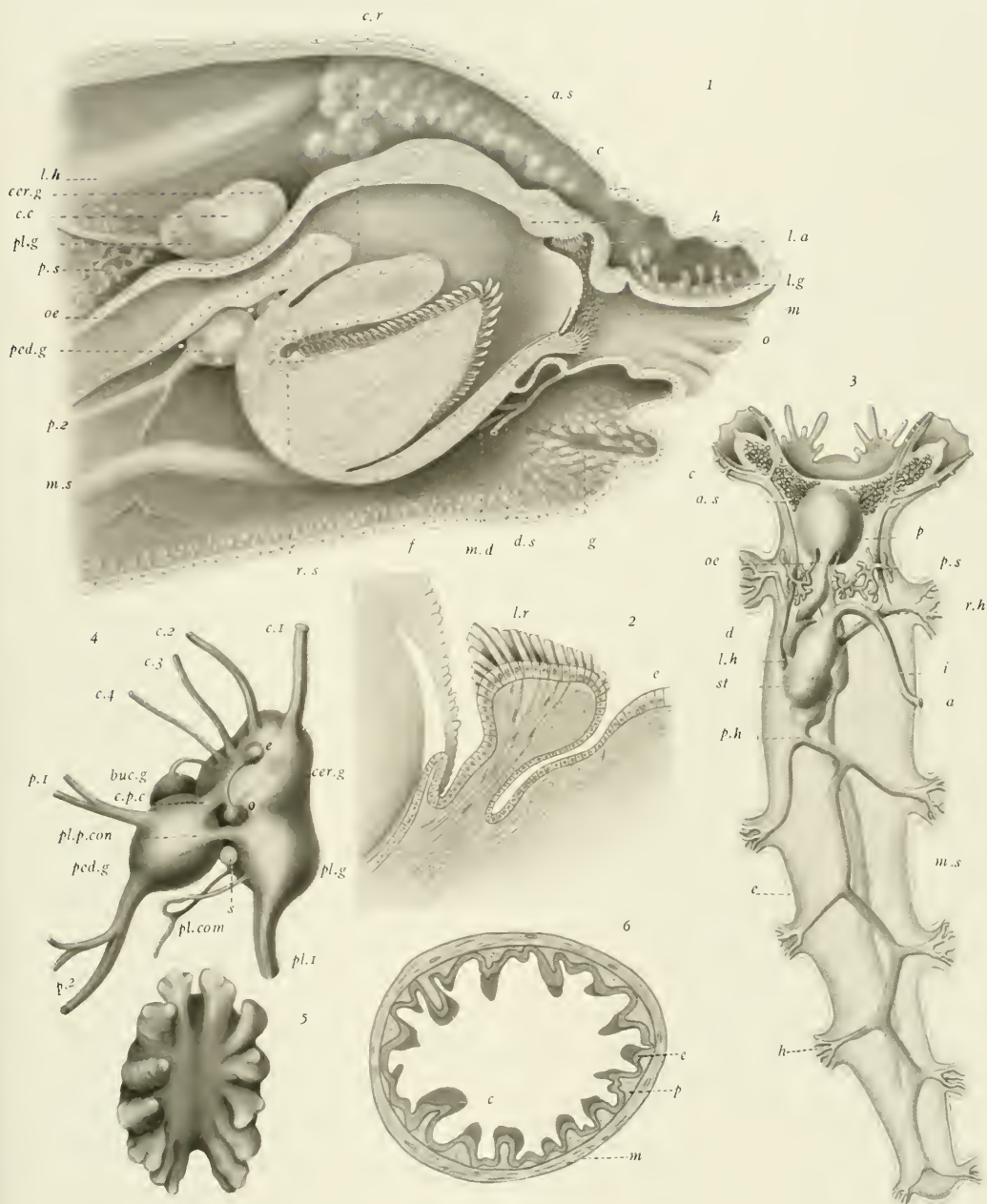
Figures reproduced from MacFarland, "The Morphology of the Nudibranch Genus *Hancockia*." 1923.

Figs. 1-6. ***Hancockia californica*** MacFarland  
(Pages 246-254)

- Fig. 1. Reconstruction of anterior end of *Hancockia* in median longitudinal plane, from serial sections; *e.*, external epithelium; *f.*, foot; *o.*, oral tube; *l. a.*, labial armature; *m.*, cutting edge of mandible; *h.*, hinge of mandibles; *r. s.*, radula sac; *c. r.*, cuticular ridge of the radula; *oe.*, oesophagus; *a. s.*, a portion of the left anterior salivary gland, its duct appearing below to join its fellow of the opposite side *d. s.*, and the unpaired duct *m. d.*, in a common median tube and opening ventrally into the oral tube immediately in front of the labial armature; *p. s.*, posterior salivary gland of the left side; *l. g.*, labial glands above the mouth; *g.*, glands below the mouth, and glands of the anterior end of the foot; *ccr. g.*, inner face of the left cerebral ganglion, fused behind with the left pleural ganglion, *pl. g.* Near the center of this ganglionic mass is seen the transverse section of the cerebral commissure, *c. c.* Below the oesophagus is seen the inner face of the left pedal ganglion, *pcd. g.*; near its center the transection of the large pedal commissure, near its lower border the parapetal commissure in section; close behind it and above the origin of the left posterior nerve, *p. 2.*, the pleural commissure is likewise seen in cross section; in front of the pedal ganglion in the angle between the ventral wall of the oesophagus and the posterior wall of the buccal mass appears the inner face of the left buccal ganglion, with the buccal commissure in cross section, and between the buccal ganglion and the pedal ganglion the sub-cerebral commissure is shown, *l. h.*, left hepatic duct, passing to the left rhinophore.  $\times 46$ .
- Fig. 2. Transverse section of labial armature on ventral side of mouth; *e.*, epithelium of mouth tube; *l. r.*, labial rodlets, borne as cuticular differentiations on the oral tube epithelium, arranged in a complete circle surrounding the inner mouth opening, immediately in front of the mandibles. These rodlets are borne on a prominent muscular ridge, here shown in cross section. The outer group of muscles of this ridge form the constrictor oris muscle, and is seen here in cross section; immediately within it is found a group of radial fibers, forming a dilator oris muscle, some of the fibers are here shown. The anterior portion of the mandible is shown in perspective, its irregularly dentate masticatory margin, extending downward to the tip of the masticatory process behind the labial armature.  $\times 257$ .
- Fig. 3. Dorsal view of reconstruction of alimentary system, based on horizontal serial sections, supplemented by dissections. The body wall is represented as cut through at the upper level of the cerata stalks, the incision passing lengthwise through the retracted rhinophores; *p.*, pharyngeal bulb seen from above and behind; *a. s.*, anterior salivary glands, extending out axially into the stalk of the rhinophore nearly to the summit of the bulb; *m. s.*, the unpaired median salivary gland; *p. s.*, posterior salivary glands, branching tubular organs; *oe.*, oesophagus; *d.*, oesophageal diverticulum; *st.*, the thick-walled grinding stomach below which is the thin-walled, ventral, anterior, gastric division giving off two anterior hepatic ducts, *r. h.*, and *l. h.*, behind the single posterior duct, *p. h.*, sending rami to the posterior cerata; *h.*, branching tubules. The anterior hepatic ducts pass into the rhinophores, numerous branches passing to the margins, terminating in the numerous endosacs, *c.*; *i.*, the intestine opening on the right side at *a.*, the anus.  $\times 74$ .
- Fig. 4. Lateral view of central nervous system.  $\times 49.5$ .

The following abbreviations designate respective parts of the figure:

- buc. g.*, buccal ganglion.  
*cer. g.*, cerebral portion of cerebro-pleural ganglion complex.  
*c. p. c.*, cerebro-pedal connective.  
*c. 1.*, first cerebral nerve to rhinophore.  
*c. 2.*, second cerebral nerve to the mouth region.  
*c. 3.*, third cerebral nerve to the anterior tentacles.  
*c. 4.*, fourth cerebral nerve to mouth region.





*e.*, eye, at the end of the optic, or fifth cerebral nerve.

*o.*, optic ganglion.

*ped.g.*, pedal ganglion.

*pl.g.*, pleural portion of cerebro-pleural ganglion complex.

*pl.p.con.*, pleuro-pedal connective.

*pl.com.*, pleural commissure.

*pl.l.*, pleural nerve to dorso-lateral body wall and cerata.

*p.1.*, first pedal nerve, to anterior end of foot.

*p.2.*, second pedal nerve, dividing into median and posterior pedal nerve trunks.

*s.*, statocyst, its nerve, the sixth cerebral, only visible in sections.

- Fig. 5. Detail of first cerata of the right side of well-preserved specimen, as seen from in front. The nodular prominences upon the subdivisions contain the cnidosacs.  $\times 13.2$ .
- Fig. 6. Transverse section of posterior grinding stomach division; *m*, circular muscle layer; *p*, sub-epithelial stratum of connective tissue; *e*, gastric epithelium, thrown into numerous folds and elevations which are capped by strong tooth-like cuticular thickenings. *e*.  $\times 86$ .



## PLATE 54

Figs. 1-10. *Chioraera leonina* Gould

(Pages 280-287)

- Fig. 1. Reproductive system. A general view is presented in the figure, the parts displaced only sufficiently to make clear their relations. The figure follows, from the ovotestis, the male and female organs separately, to the external openings.  $\times 8$ .
- Fig. 2. The proximal end of the uterus and the junction of the oviduct. The oviduct enters a caecum-like dilation, receives laterally a series of closely set, short, sac-like diverticula, *a*.  $\times 22$ .
- Fig. 3. Enlarged detail of the uterus, represented as a transparent object segment at *b*. Following the proximal end, the simple diverticula become thrown into secondary folds as shown in this figure.  $\times 22$ .
- Fig. 4. Cross section of the uterus showing two distal parts of the diverticula; the secondary folds open by wide apertures.  $\times 135$ .
- Fig. 5. Cross section of the uterus near the proximal end *a*; simple sac-like diverticula with low, ciliated, columnar cells.  $\times 135$ .
- Fig. 6. Central nervous system; view from above.  $\times 37$ .
- Fig. 7. Side view showing the ganglia above the oesophagus, passing under are the pedal and parapedal commissures, in front of them the delicate buccal ganglia and their commissure.  $\times 37$ .
- Fig. 8. Ventral view; this shows the pedal and parapedal commissures, the buccal connective with the cerebral ganglia, and the small nerves arising from the buccal ganglia; anterior, to the pharyngeal bulb, posterior, to the stomach. The salivary glands are shown in both side and ventral views.  $\times 37$ .
- Fig. 9. Detailed drawing showing the narrowed distal end of the ampulla, the oviduct, and vas deferens lying above the prostate gland. The external surface of this gland presents a mulberry-like appearance, produced by distal ends of alveoli, radially arranged. Each leads into a short duct, which, uniting with similar ducts, opens into the lumen of the centrally placed vas deferens. The cut ends of several small ducts are exposed.  $\times 20$ .
- Fig. 10. Copy of Bergh's figure of a structure he described as the "fächer-formiges organ." *Mal. Unters.* Heft. 9, 1875, pp. 369-376, pl. 46, figs. 25, 26.

1



gls.p

3



b.amp

5



2



4



6

rh.n

c.g

e

st

10

ped.g

pl.g

p.com

para-p.com

pl.g

7

c.g

oes

c.b.con

sal.gl

b.com

p.com

para-p.com

pr.g

8

vas.d

sol.gl

c.g

b.com

p.com

para-p.com

ped.g

## PLATE 55

Fig. 1. ***Hermisenda crassicornis*** (Eschscholtz)

(Pages 358-365)

- Fig. 1. Painting from living specimen collected from Monterey Bay. Size of mature specimens range from 30 to 70 and 80 mm. in length. The specimen painted was 40 mm. long. It depicts the characteristic color markings of all large specimens. These have been found to be constant.  $\times 5$ .



## PLATE 56

Figs. 1-4. ***Dirona albolineata*** MacFarland  
(Pages 298-302)

- Fig. 1. Dorsal view, directly from above.  $\times 2.7$ .  
Fig. 2. Oblique profile view from in front and above.  $\times 3.2$ .  
Fig. 3. Ventral view of the head; mouth, anterior edge of foot, and wide and undulating margin are shown.  $\times 2.7$ .  
Fig. 4. Left rhinophore from behind and within. A white band extends, on the inner side, from the clavus down the stalk, uniting with that of the opposite rhinophore.  $\times 5.4$ .

Figs. 5-7. ***Dirona picta*** MacFarland  
(Pages 296-298)

- Fig. 5. Left side. Inner surface of the cerata on right side showing the tuberculate divisions.  $\times 3.2$ .  
Fig. 6. Ventral view of head; veil very undulating with thin, transparent margin.  $\times 5$ .  
Fig. 7. Clavus of rhinophore from behind.  $\times 8$ .



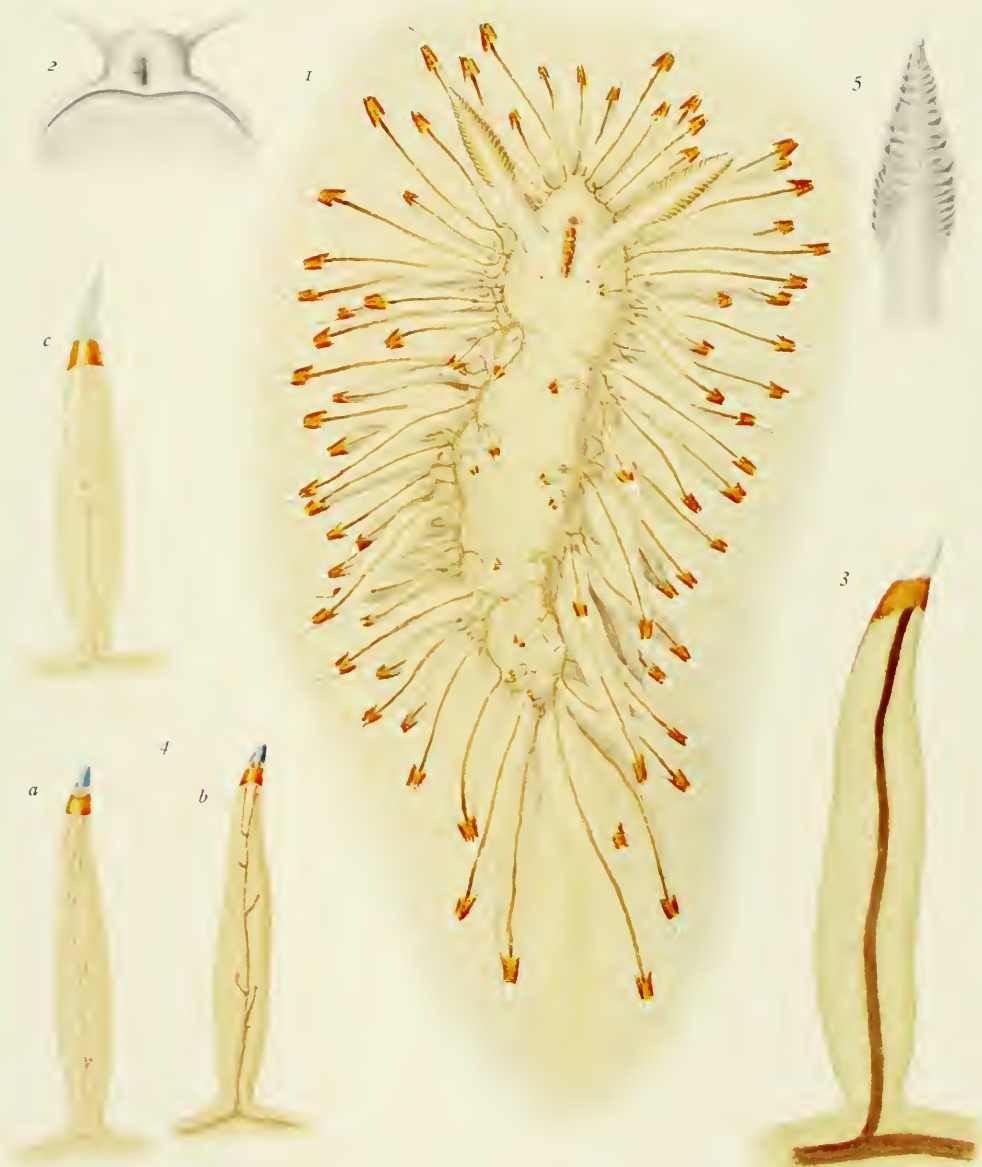


## PLATE 57

Figs. 1-5. *Antiopella aureocincta* MacFarland, new species

(Pages 303-308)

- Fig. 1. Figure of Monterey Bay specimen, dorsal view.  $\times 8$ . Painted by Anna B. Nash.
- Fig. 2. Ventral view of head, cerata omitted. These extend from the margin of the head half their length when seen from below, forming a semicircle.  $\times 8$ .
- Fig. 3. An enlargement of a single ceras from the painted specimen. Those taken from Monterey Bay showed the liver duct as a single branch from base to tip.  $\times 12.6$ . Painted by Anna B. Nash.
- Fig. 4. Three cerata of specimen taken from Newport Bay. Two individuals were studied carefully for color. One had the cerata tips a very deep blue, below a band of orange, metallic in its brightness. Within, the liver branches were irregularly branched and thickened, terminating in several slender branches showing under the surface bands of color at the tips; *a* and *b* are examples. The second specimen was of lighter coloring, the ceras, *c*, was taken from the head group where they seemed generally to have paler blue tips extending down one-fourth of the length. The rhinophores also were blue on upper half.  $\times 8$ .
- Fig. 5. Rhinophore from the back, showing a slight ridge, and short intermediate leaves.  $\times 10$ .



## PLATE 58

**Figs. 1, 2. *Flabellinopsis iodinea* (Cooper)**  
(Pages 308-313)

- Fig. 1. This represents the right side of a most striking acolid. It measured 35 mm. in length, with a general body color of clear translucent purple of an amethyst shade. Brilliant blue covers the tips of the tail and anterior tentacles, while the body color extends up the basal portion of the rhinophores and cerata. The deep, maroon, burnt sienna of the clavus plates lends a very dark spot. However, the most striking coloring is found on the cerata: the flaming scarlet (orange and vermillion) with marginal accents has been impossible to attain even with transparent water colors and years of effort.  $\times 4.7$ .
- Fig. 2. Enlargement of a single ceras.  $\times 20$ .

**Figs. 3-5. *Coryphella fisheri* MacFarland, new species**  
(Pages 318-322)

- Fig. 3. Dorsal view of a specimen 15 mm. in length. The white lines, which are a constant character of this genus, are easily seen in the tide pools. The brilliant liver branches almost fill the cerata, leaving a transparent margin of the integument. Numerous in very rocky pools.  $\times 10$ . Painted by Anna B. Nash.
- Fig. 4. Shows clearly this coloring of the cerata in this enlarged ceras.  $\times 40$ . Painted by Anna B. Nash.
- Fig. 5. Right side of a darker specimen is represented. The liver lobules are frequently dark, shading from base to tip of cerata.  $\times 10$ . Painted by Anna B. Nash.

**Fig. 6. *Coryphella pricei* MacFarland, new species**  
(Pages 313-318)

- Fig. 6. A rare species is shown here. The diverticulum of the liver, a deep olive green, occupies each ceras. A band of harmonious brown is found below each frosted tip.  $\times 11$ .



## PLATE 59

Figs. 1, 2. **Cuthona rosea** MacFarland, new species  
(Pages 326-332)

- Fig. 1. Profile view, head turned ventrally, showing the thickened lips, position of the mouth, both anterior tentacles; the cerata extending in a circle in front of the rhinophores.  $\times 10$ .  
Fig. 2. Ventral view of the head parts, showing the mouth, thickened anterior margin of the foot, the rhinophores extending forward back of the most anterior cerata. Drawing from an alcoholic specimen.  $\times 9$ .

Figs. 3, 4. **Cratena abronia** MacFarland, new species  
(Pages 347-351)

- Fig. 3. Left side is shown full length. This is a very small aeolid, strikingly colored, largely because of the color bands on the rhinophores and the unusual division of the liver branches which fill the cerata with two distinct colors, most exactly divided.  $\times 14$ .  
Fig. 4. An enlarged drawing of a cerata to show more clearly the liver colorings and the bands of surface white, all terminating in a pale yellow tip and bounded by the transparent integument.  $\times 70$ .





## PLATE 60

Seven very small rare aeolids have been placed in the genus *Cratena*. These are figured on this and the following plate.

Fig. 1. ***Cratena rutila*** MacFarland, new species  
(Pages 332-336)

Fig. 1. Dorsal view of a specimen crawling freely so that the length is much exaggerated. Measurements were taken from tip of tail to the median anterior margin of the head. This one measured 11.5 mm. in length.  $\times 15$ .

Fig. 2. ***Cratena flavovulta*** MacFarland, new species  
(Pages 336-337)

Fig. 2. An oblique view, looking directly at the orange-colored head. Length 10 mm.  $\times 16$ .

Fig. 3. ***Cratena fulgens*** MacFarland, new species  
(Pages 337-340)

Fig. 3. The smallest of the group is but 5 mm. in length, .5 mm. wide. The rhinophore and one ceras are each but 1 mm. long.  $\times 30$ .

Fig. 4. ***Cratena spadix*** MacFarland, new species  
(Pages 351-354)

Fig. 4. The left side is shown in full length. There seems to be a divergence in the shape of the cerata in this species; lines are very marked; length 12.5 mm.  $\times 12$ .



## PLATE 61

Figs. 1-4. **Cratena albocrusta** MacFarland, new species  
(Pages 340-344)

- Fig. 1. Dorsal view; cerata spindle-shaped, large, inflated. These are almost filled by the terminal branches of the liver which varies from a dark rich green to a paler shade. The white encrusting of the dorsum and the surface of the cerata is most pronounced.  $\times 12$ .
- Fig. 2. A slightly smaller specimen is represented in profile. This shows the distribution of the white on sides above the foot, and the egg follicles below the integument, as a yellow mass.  $\times 12$ .
- Fig. 3. The species is also found with the liver branches in shades of brown. A ventral drawing shows the head and foot parts clearly, the cerata in rows protruding from the sides.  $\times 6$ .
- Fig. 4. Detail of ceras, greatly enlarged. This makes clear the terminal distribution of the liver branches and the cnidosac at the point under the integument.  $\times 17$ .

Fig. 5. **Cratena virens** MacFarland, new species  
(Pages 344-347)

- Fig. 5. Dorsal view from above and in front. Only one specimen of this smallest and rarest of all aeolids was found. This was in June, 1905, taken from the Large Tide Pool at Point Pinos. Careful measurements were taken and several colored sketches made.  $\times 34$ .



## PLATE 62

Figs. 1-3. **Phidiana nigra** MacFarland, new species  
(Pages 366-370)

- Fig. 1. View from above, representing the nudibranch as crawling toward the observer; the genile curve shows the wide, thin, transparent foot which extends well beyond the sides. The first group of cerata form a large dense mass falling over the sides. The brown umber of the liver darkens the large inner cerata which terminate in the pure white tip with an irregular spot below, concealing the liver tips; over the surface is a wash of madder carmine. The closely set, small, outer processes are completely filled by the liver branches and tipped with orange.  $\times 5$ .
- Fig. 2. The enlarged ceras makes clear the color distribution.  $\times 11$ .
- Fig. 3. Enlarged left rhinophore viewed from the front.  $\times 10$ .

Figs. 4-6. **Aeolidiella oliviae** MacFarland, new species  
(Pages 373-377)

- Fig. 4. The figure gives a full dorsal view. Body color inclined to cream. Liver branches raw umber, terminating in white tips with an inner distinct cone. Cerata a brilliant orange-vermilion; surface color intensified on the inner margins; plates of the clavus are very pronounced.  $\times 7$ .
- Figs. 5,6. Enlarged cerata from the inner right and left rows.  $\times 22$ .

Fig. 7. **Eubranchus occidentalis** MacFarland, new species  
(Pages 323-326)

- Fig. 7. Its minuteness, 10 mm. long, together with the unusual cerata, makes it difficult to find in the tide pool, it is so perfectly matched to the habitat hydroid. The patterns shown are constant. Two colorings are found in Monterey Bay, those with liver branches of yellow brown and the more beautiful one of green coloring, which the figure shows. Food doubtless is a factor, but it cannot explain the metallic sheen of the bands encircling the cerata.  $\times 10$ .





## PLATE 63

Figs. 1-8. *Dirona picta* MacFarland

(Pages 296-298)

- Fig. 1. Median tooth, view from above.  $\times 150$ .  
 Fig. 2. Median tooth, two views, from the side and below, showing base.  $\times 150$ .  
 Fig. 3. First lateral tooth, three views; *a*, dorsal; *b*, ventral; *c*, inner face.  $\times 150$ .  
 Fig. 4. Second lateral tooth, obliquely from below.  $\times 150$ .  
 Fig. 5. Detail of denticles of first lateral.  $\times 350$ .  
 Fig. 6. Mandibles in position seen from the right side, turned to show the edge of the opposite mandible; *w*, wing; *h*, hinge ligament; *m*, masticatory portion.  $\times 10$ .  
 Fig. 7. Inner face of mandible; *w*, wing; *h*, hinge ligament; *m*, masticatory surface; *c*, chitinous band.  $\times 10$ .  
 Fig. 8. Mouth armature, both mandibles, isolated by dissection; as seen obliquely from above.  $\times 10$ .

Figs. 9-12. *Dirona albolineata* MacFarland

(Pages 298-302)

- Fig. 9. Median tooth, two views, from above and in profile.  $\times 150$ .  
 Fig. 10. First lateral, three views; *a*, obliquely from above; *b*, ventral; *c*, in profile.  $\times 150$ .  
 Fig. 11. Second lateral, large compressed tooth.  $\times 150$ .  
 Fig. 12. Inner face of mandible; *w*, wing portion; *m*, masticatory surface; *h*, hinge ligament; *c*, chitinous band connecting the mandibles.  $\times 10$ .

Figs. 13-30. *Antiopeella aureocincta* MacFarland, new species

(Pages 303-308)

- Fig. 13. Median tooth and first two laterals from above.  $\times 135$ .  
 Fig. 14. Two laterals, first row; *a*, ventral face; *b*, inner face.  $\times 212$ .  
 Fig. 15. Median tooth, higher magnification, showing the posterior thickened end with the rounded median cusp; anterior border narrowed, thin, with deep median notch and irregular edge.  $\times 312$ .  
 Fig. 16. Fifth and sixth laterals of the fifth row, obliquely from the side.  $\times 135$ .  
 Fig. 17. Laterals as in figure 16, at a slightly different angle.  $\times 135$ .  
 Fig. 18. The mandibles are figured in five views. This first one shows direct view of the thinner margin, the outer thicker convex margin, the shield-like expansion with its masticatory process bearing pointed triangular teeth.  $\times 15$ .  
 Figs. 19-22. These figures show the same mandible rotated to the left, exposing the mandible at a slightly different angle with each change in position, thus giving a clear understanding of the most unusual shape. The last figure, number 22, gives a direct view obliquely from above of the inner surface, the apex or hinge ends with the masticatory process on the outer margin. All figures  $\times 15$ .  
 Fig. 23. This figures a section through the cutting edge of the mandible, *c*, just posterior to the teeth of the masticatory margin, *m*.  $\times 20$ .  
 Fig. 24. Section through the cutting edge of the mandible.  $\times 20$ .  
 Fig. 25. Section near the posterior end of mandible, which end lies below the central nervous system.  $\times 20$ .  
 Fig. 26. Two tracings from *Janolus australis* Bergh, 1874. Challenger Report, plate 8, figure 16, *a*, outer face left mandible, figure 17, *b*, inner face.  
 Figures 27, 28 show two drawings made from celloidin serial sections across the pharyngeal bulb. Details of the histological structure of the mouth parts are clearly shown.  
 Fig. 27. This section cuts across the mandible in the central part, passes through the oesophagus, ducts of the salivary glands, and radula, showing the teeth. A strong transverse ventral





muscle spans the space between the mandibles. A chitinous layer covers the mandibles beneath which is a homogeneous substance. This clear matrix is divided by a horizontal lamina of a fibrous nature as at *a*; on the inner fourth these fibers fan out in a network as seen at *b*.  $\times 36$ .

- Fig. 28. Cross section through the bulb near the posterior end of the mandibles. The buccal ganglia lie above with the oesophagus between the posterior section of the radula below. The chitinous covering of the mandibles, the homogeneous interior with its fibrous lamina, are as in figure 27. Above and below them the muscle fibers are cut obliquely and between them are pads of cellular cartilage with the ventral transverse muscle below.  $\times 36$ .
- Fig. 29. Drawing made from a section of a celloidin series of ten slides cut transversely through the entire animal. This figures but one side of the mouth, the other being oblique, but shows fine radula teeth, one mandible, and below it a tooth of the masticatory margin with its thick covering of chitin. The indentation in the chitin over the mandible at *x* continues through several sections, its relations uncertain. The thickened ridge of oral cuticle doubles forward to fuse with the anterior foot margin, medially extending across below the mouth at *r*.  $\times 120$ .
- Fig. 30. Drawing made from a section of the celloidin series across the pharyngeal bulb. The section passes close to the mouth opening. It cuts through the mandible with its chitinous covering, the homogeneous interior, traversed by the fibrous lamina. Below is a tooth of the masticatory process with its heavy covering of chitin. The inner substance which supports this covering is composed of a reticulum with minute nuclei at nodal points and contains large blood-vessel-like cavities. The lip below is covered by the mouth cuticle which splits into rod-like extensions.  $\times 48$ .

## PLATE 64

Figs. 1-3. *Dirona picta* MacFarland

(Pages 296-298)

- Fig. 1. Reproductive system. The parts have been separated to more clearly show their relations. The hermaphroditic gland is divided into a number of prismatic lobes. The small duct expands into a wide ampulla which lies in a double loop upon the complex. It narrows suddenly and bifurcates into the vas deferens and the oviduct. The vas deferens is very long, passing through its glandular segment to the muscular coils at the base of the preputium where there is a strong sphincter muscle. The oviduct, too, is long; at the point of division it does not enter the genital complex but continues with many loops and dilates into an enlarged segment which leads to its opening into the inner portion of the genital atrium, a cavity crescentic in cross section within the female opening. Into this cavity the slender duct from the small blind sac, the spermatheca, opens just behind the opening of the oviduct; the lower part of this crescentic channel within the atrium corresponds to the duct of the accessory glands.  $\times 8.5$ .
- Fig. 2. The preputium with its retractor muscle; the vas deferens, coiled at its base, enters the glans penis and passes to the external opening.  $\times 15$ .
- Fig. 3. Drawing, made from a microscopic section, showing the duct of the vas deferens as it has entered the duct of the preputium.  $\times 15$ .

Figs. 4-10. *Dirona albolineata* MacFarland

(Pages 298-302)

- Fig. 4. Reproductive system. The ducts have been separated slightly in order to show the relations more clearly. The extruded glans is a tapering conical organ which lies parallel to the side of the body. The hermaphroditic duct dilates into the widened ampulla with many complicated coils. This narrows and bifurcates into the oviduct and vas deferens; the former passes at once into the genital mass. The latter enters into its glandular segment of closely convoluted turns. The connection of the distal muscular segment, at the base of the preputium, is obscure. A segment of the vestibular wall, to which the retractor muscle is attached, completely covers the external opening. The large spermatheca lies beside the ampulla. Its muscular duct connects with the vagina which is hidden.  $\times 8$ .
- Fig. 5. Extruded glans, showing conical elevations, or papillae, arranged in circles around it; these projections are terminated by thorn-like points, resembling, in profile, the thorns of a rose directed outward.  $\times 10$ .
- Fig. 6. This drawing shows, obliquely from behind and within, the large spermatheca with its broad muscular duct which is turned under upon itself as it approaches the vagina. This, having a sphincter muscle at its vulvar opening, is a roomy lumen leading to the external opening.  $\times 8$ .
- Fig. 7. This figure shows the detail of the division of the hermaphroditic ampulla into the vas deferens and the oviduct, where it is hidden in figure 4. The oviduct passes at once into the nidamental gland, the vas deferens entering its glandular segment.  $\times 10$ .
- Fig. 8. The retractor muscle has its base attached to the inner end of the glans penis, passes around and above the coils of the vas deferens to the left body wall where it is inserted.  $\times 10$ .
- Fig. 9. External reproductive openings; two openings are conspicuous; the anterior one is that of the glans penis which is seen extruded; below this and at the top of the crescentic groove, is that of the vagina; the groove deepens into the opening of the nidamental gland, the oviduct opening at the lowest point. The anterior border is prolonged into a triangular flap at *a*.  $\times 5$ .
- Fig. 10. Diagram showing, in ventral view, the lobes of the liver in their relations to the stomach and its ducts; the bulk of the liver lies on the left side and posteriorly. It is divided into







left antero-lateral lobe, *a*, and a larger postero-ventral one, *b*. The anterior lobe appears as an elongated mass, extending from left to right. The stomach is opened exposing two ducts; No. 1, is large, arising from the greater curvature of the stomach, the first branch passes forward to the left antero-lateral lobe, *a*; the second branch passes back and ramifies the postero-ventral lobe, *b*. On the lesser curvature, opposite to duct No. 1, is a second duct, No. 2. This leads into the ventro-anterior lobe which is exposed on the ventral face.

Figs. 11-17. *Antiopella aureocincta* MacFarland, new species

(Pages 303-308)

- Fig. 11. Reproductive system. Inner face, mucous and alumen glands not shown; coils of the vas deferens displaced, ampulla placed below; *h. d.*, hermaphroditic duct connects by a narrow end with the large reniform hermaphroditic ampulla, *h. amp.* From this end arises also a slender duct, lying in a groove on the inner face of the mass, terminating in a deeply lobulated sac, *s.* From the opposite end of the ampulla a slender duct arises and divides into a very short oviduct which passes at once into the gland mass; the vas deferens, arising from the same point, enlarges at once into its glandular segment; after many windings it narrows into the muscular coils and passes into the preputium through the glans penis to the external opening. The figure shows the vestibule terminating in the vagina which ends blindly. From this blind curvature arises a thin-walled, short tube which expands into the lumen of a thin-walled sac.  $\times 10$ .
- Fig. 12. Dorsal view of the genital mass before the parts were disturbed by dissection. The retractor muscle arises from the base of the preputium, passing to the opposite wall where it is attached. The proximal glandular loops and the distal muscular coils of the vas deferens are in normal position; the ampulla lies upon the loops of the mucous gland; the wide vestibule leads to the external opening.  $\times 10$ .
- Fig. 13. This figure is drawn to show the position of the slender duct which is terminated by the deeply lobulated pyriform sac. The duct lies in a groove on the inner face between the mucous gland mass and a proximal loop of the vas deferens on the side of the retractor muscle.
- Fig. 14. This enlarged figure gives a clearer view of the vagina and its connections. This passes backward from the female vestibule receiving the duct of the gland complex. It narrows proximally and ends blindly. Into the loop of this curvature opens a narrow thin-walled tube. The tube expands into a lumen, *L*, which suddenly narrows, opening into the hermaphroditic duct at the juncture of the vas deferens.  $\times 15$ .
- Fig. 15. Extruded glans penis; long, slender, smooth, and unarmed.  $\times 7$ .
- Fig. 16. Dorsal view of the hepatic system. A camera-lucida drawing made from a transparent mount by aid of sunlight. The figure makes clear the source and distribution of the three large hepatic ducts arising from the stomach. These pass along the bases of the cerata groups branching dichotomously, sending one stem to the center of each ceras.  $\times 10$ .
- Fig. 17. A ventral view is here given which shows the source of the three liver ducts described above. The transparent mount shows a small duct arising from the ventral anterior curvature. The intestine is a prominent feature of the figure. It arises from the central curvature of the stomach and passes to its opening in the extreme median-posterior part of the body, anterior, however, of the last groups of cerata.  $\times 10$ .

## PLATE 65

Figs. 1-8. *Flabellinopsis iodinea* (Cooper)

(Pages 308-313)

- Fig. 1. Mandible. Inner concave face; wide triangular wing; wide masticatory surface; free edge turned inward, then backward.  $\times 20$ .  
Fig. 2. Drawing shows masticatory free margin about midway of its length. A broad surface of nodosities is presented, large on the margin, gradually reduced in size inward.  $\times 386$ .  
Fig. 3. Dorsal view of median tooth from the fourth row, central cusp rising above denticles, of almost equal size on the margin.  $\times 135$ .  
Fig. 4. Oblique view of median from seventh row.  $\times 135$ .  
Fig. 5. Lateral tooth from seventh row; central cusp strong, rising in a curve.  $\times 135$ .  
Fig. 6. Tip of seventh lateral showing detail of the denticles which are slender and closely set; strong cusp rises above.  $\times 386$ .  
Fig. 7. Lateral in profile, a much flattened tooth.  $\times 135$ .  
Fig. 8. Ventral view of first median tooth.  $\times 156$ .

Figs. 9-13. *Coryphella pricei* MacFarland, new species

(Pages 313-318)

- Fig. 9. Mandible, inner face. Single series of denticles on the masticatory margin,  $\times 37$ ; *a*, section of worn denticles near the hinge; *b*, denticles one-third back from the apex; *c*, denticles from the free margin.  $\times 312$ .  
Fig. 10. Dorsal view of first median tooth, directly from above; cusp lies below the denticles.  $\times 312$ .  
Fig. 11. Ventral of oldest median; base prolonged forward laterally giving it a deep V-shape.  $\times 312$ .  
Fig. 12. Profile of median tooth, seen obliquely from above.  $\times 312$ .  
Fig. 13. Two median teeth with laterals from the sixth and seventh rows, at the angle of the radula. Lateral teeth flattened, thin, oblique, triangular plates.  $\times 312$ .

Figs. 14-18. *Coryphella fisheri* MacFarland, new species

(Pages 318-322)

- Fig. 14. Detailed drawing of mandible hinge and masticatory margin; process short; denticles conical, blunt, arranged in longitudinal rows.  $\times 212$ .  
Fig. 15. Inner face of entire mandible.  $\times 32$ .  
Fig. 16. Figure shows three median and lateral teeth from rows three, four, five, at the angle of the radula. Anterior limb prolonged fits into depression of succeeding tooth. Lateral teeth are flattened, triangular plates, inner margin with 6 to 12 denticles.  $\times 212$ .  
Fig. 17. First median tooth seen obliquely from below.  $\times 212$ .  
Fig. 18. Profile of a lateral tooth showing the outer margin prolonged forward.  $\times 212$ .

Figs. 19-25. *Eubbranchus occidentalis* MacFarland, new species

(Pages 323-326)

- Fig. 19. Mandible, inner concave surface; wing with strong, ridge-like growth lines; one row of denticles on masticatory margin.  $\times 110$ .  
Fig. 20. Cutting edge of mandible. Single row of denticles, worn near the hinge; below, transverse plate-like ridges with fine serrulations on the edge.  $\times 880$ .  
Fig. 21. Four median and three lateral teeth at the angle of the radula; profile view of the median, dorsal of the laterals; the median cusp, a strong hook bent downward below the level of the lateral denticles.  $\times 650$ .  
Fig. 22. Profile of median from the 12th row, the youngest part of the radula. The relation of the cusp to the base and the lateral denticles clearly shown.  $\times 650$ .  
Fig. 23. Median tooth from the 45th row, dorsal view.  $\times 650$ .  
Fig. 24. Ventral view from above median tooth. The base, with a deep arch, bears three rounded projections, one at the base of the median cusp, one on either side just posterior of the central one, all so placed that they fit into depressions of the succeeding tooth.  $\times 650$ .  
Fig. 25. Dorsal view of median tooth from the oldest end of the radula.  $\times 650$ .



## PLATE 66

Figs. 1-6. *Flabellinopsis iodinea* (Cooper)

(Pages 308-313)

- Fig. 1. Reproductive system. Nidamental-albumen glands have been removed to more clearly show the other parts. The hermaphroditic duct bifurcates. The vas deferens is seen as a long tube of many turns, reaching the external opening through the thick bluntly conical glans. The vagina dilates into a roomy cavity with muscular walls. The duct opens on the side of the proximal end of this cavity. The figure shows the wall of the vestibulum removed, revealing a number of longitudinal folds near the opening; others are found within.  $\times 7.5$ .
- Fig. 2. Drawing made from a dissection of the anterior genital mass, undisturbed. The flattened inner face is shown; the vas deferens cut and reflected; exposing the glands.  $\times 6.5$ .
- Fig. 3. External reproductive openings; the glans everted into a bell-like form, narrow at the base, expanding and terminating in a blunt tip, which is a circular disk flattened and bounded by a white ring, but no sign of external armature. The opening of the female ducts forms a semicircle below that of the penis.  $\times 10$ .
- Fig. 4. Ventral view of the head regions.  $\times 2$ .
- Fig. 5. A camera-lucida drawing of the anterior group of cerata on the right side. It is given here in part only, and the tips from the left side are omitted. In general, the arrangement is in oblique rows extending outward and backward. They are not borne in groups upon arm-like processes of the body margin, but upon slight elevations from the lateral edge. This first major group of cerata extends from in front of, and exterior to the rhinophores backward, to immediately in front of the cardiac elevation forming an arch above the reproductive openings. The cerata of the group are closely set including 13 rows anterior of the anus. The figure shows but 8 rows and 37 ceras.  $\times 4.5$ .
- Fig. 6. Oblique view of head from the front, same specimen as for figure 5. Mouth, anterior tentacles, grooved angles of the foot, rhinophore, first row of cerata, all visible.  $\times 4.5$ .

Fig. 7. *Eubranchus occidentalis* MacFarland, new species

(Pages 323-326)

- Fig. 7. Reproductive system. A large accessory gland joins the vas deferens at the base of the preputium. The oviduct enters the nidamental gland near the external opening of the genital glands. The vagina, which is terminated at its proximal end by the spermatheca, has its vestibular opening just below that of the glans penis.  $\times 37$ .

Figs. 8, 9. *Coryphella pricei* MacFarland, new species

(Pages 313-318)

- Fig. 8. In the genital mass the prostate segment of the vas deferens lies parallel to the preputium, making a sharp turn, entering the base of the glans penis, a blunt cone. The vaginal duct emerges from the nidamental gland near the entrance of the oviduct. It dilates into the vagina which passes to the external opening in the vestibulum; here it is joined by the duct of the spermatheca lying near it.  $\times 37$ .
- Fig. 9. Ventral view of the head parts. Oral tentacles are deeply grooved.  $\times 5$ .

Figs. 10-20. *Coryphella fisheri* MacFarland, new species

(Pages 318-322)

- Fig. 10. Drawing shows the head and anterior margin of the foot, the angle prolonged as short tentacles, which are not grooved.  $\times 6$ .







- Fig. 11. Reproductive system. In general the parts are as described for *C. pricei*, but depart markedly in some places. The ampulla bifurcates; the short vas deferens enters at once its prostatic segment which continues to the base of the preputial sac. This incloses a complicated organ, the glans penis, a roughly triangular lobe terminating in a point. A second lobe becomes connected, all irregularly folded and densely glandular. The oviduct is very short, receiving the duct from the spermatheca before it enters the nidamental gland. Arising from this is a sac-like tube, opening by a slender duct into the crescentic atrial cavity which also receives the bursa copulatrix.  $\times 24$ .
- Fig. 12. The everted glans is short, tumid, oval in outline. Its anterior margin is prolonged upward into a pointed claw-like tip, directed backward. Immediately behind this tip is the anterior end of the elongated, slit-like, apical opening of the deferent duct, closely lined with large narrow, secreting cells. Immediately behind and slightly above the everted glans, is a large linear opening of a sinus into which open the vagina above, and the duct from the nidamental-albumen glands.  $\times 12$ .
- Fig. 13. Sectional drawing from a sagittal series, through the glans penis; showing the narrow basement epithelium of cuboidal ciliated cells and the thick walls, densely glandular.  $\times 48$ .
- Fig. 14. Cross section from a series of the entire animal. Section passes through the glans along the line *a-a*, figure 13; nidamental cells appear at *a*; female duct at *b*; genital sinus at *c*. In the following row of the series, the external opening appears at *x*. The stomach and oesophagus also appear in the drawing.  $\times 48$ .
- Fig. 15. Two cells from the wall of the glans, at region 2, figure 13. Vacuoles appear on the free border, inclosing large secretion granules.  $\times 627$ .
- Fig. 16. Three cells from a tubular gland in the wall of the glans penis; base filled with vacuoles.  $\times 705$ .
- Fig. 17. Section of the vas deferens at its division from the large hermaphroditic duct; beyond the ampulla, before the prostatic segment is reached.  $\times 127$ .
- Fig. 18. Three ciliated cells from the wall of the vas deferens.  $\times 470$ .
- Fig. 19. Cells from the prostatic segment of the vas deferens. Between these glandular cells is a series of much smaller oval nuclei arranged in a single row. These seem to belong to slender cells wedged in between the glandular ones.  $\times 752$ .
- Fig. 20. As the glandular zone thickens, differentiated tubular glands appear. These are made up of cells similar in structure to those described in above figures, but they are invaginated in groups to form tubular glands.  $\times 243$ .

## PLATE 67

Figs. 1-6a. *Cratena rutila* MacFarland, new species

(Pages 332-336)

- Fig. 1. Three teeth of the radula, dorsal view; central cusp rounded and elevated as a ridge, the rounded end extending beyond the inner curved margin.  $\times 386$ .  
Fig. 2. Ventral surface of three teeth showing the pocket of the articulation.  $\times 386$ .  
Fig. 3. Two teeth close to the angle, seen from the side, rounded down under the central cusp.  $\times 386$ .  
Fig. 4. Section through the 55th tooth, just beyond the angle.  $\times 386$ .  
Fig. 5. Mandible; deep concave inner surface, free margin rolled outward.  $\times 40$ .  
Fig. 6. Mandible seen obliquely in profile; showing the sharp free edge and hinge region.  $\times 40$ .  
Fig. 6a. Denticles from the masticatory process, single row.  $\times 650$ .

Figs. 7, 12. *Cratena flavovulta* MacFarland, new species

(Pages 336-337)

- Fig. 7. Three teeth from the radula, seen from above; number one, the oldest; 34th from the angle; 61st, the youngest. Median spine very prominent, inner end enlarged and knob-like, extending beyond the inner curved margin. Outline of the ventral pocket seen from above.  $\times 386$ .  
Fig. 12. Denticles of the masticatory margin of the mandible.  $\times 650$ .

Figs. 8-11. *Cratena fulgens* MacFarland, new species

(Pages 337-340)

- Fig. 8. Dorsal view of three radula teeth; No. 1, the oldest; 31st from center of radula; 57th, young tooth.  $\times 386$ .  
Fig. 9. Top of mandible showing the hinge region, wing of the masticatory process.  $\times 45$ .  
Fig. 10. Rounded denticles from the short masticatory process.  $\times 650$ .  
Fig. 11. Outline drawing of the mandibles of the three above species. The figure shows the difference in size and similarity in form. Outer one, *a*, *C. rutila*; middle one, *b*, *C. flavovulta*; inner one, *c*, *C. fulgens*.

Figs. 13-22. *Cratena albocrusta* MacFarland, new species

(Pages 340-344)

- Fig. 13. Dorsal view of two teeth from the center of the radula. Central cusp shorter than the first laterals. Base merges with the inner margin.  $\times 530$ .  
Fig. 14. Ventral of the two radula teeth of figure 13.  $\times 530$ .  
Fig. 15. Thirtieth and 31st teeth seen in profile. Median cusp strong.  $\times 530$ .  
Fig. 16. Median section through the cusp of tooth beyond the angle.  $\times 530$ .  
Fig. 17. Inner face of the left mandible.  $\times 45$ .  
Fig. 18. The tip of the margin of the masticatory process, denticles pointed and sharp.  $\times 530$ .  
Fig. 19. Long duct of posterior or post-bulbar salivary glands; cuboidal epithelium on one side; on opposite side large secreting cells.  $\times 212$ .  
Fig. 20. Cross section of post-salivary gland duct, glandular cells surrounding the lumen.  $\times 212$ .  
Fig. 21. Cross section of gland duct, secreting cells on but one side of the lumen.  $\times 212$ .  
Fig. 22. Cells from the anterior or pre-bulbar salivary glands, two in a group, binucleate.  $\times 212$ .



## PLATE 68

Figs. 1-7. *Cuthonia rosea* MacFarland, new species

(Pages 326-332)

- Fig. 1. Mandible, inner concave face. Thickened and ridged along the margin of the mandibular process and hinge region.  $\times 40$ .  
Fig. 2. Denticles, outer face of masticatory margin; worn and misshapen near the hinge.  $\times 386$ .  
Fig. 3. Dorsal view of 30th tooth.  $\times 212$ .  
Fig. 4. Ventral surface, oblique view; curve of base and denticles clearly seen.  $\times 212$ .  
Fig. 5. Ninth, oldest tooth, in profile.  $\times 212$ .  
Fig. 6. Ninth tooth, oblique from below.  $\times 212$ .  
Fig. 7. Third and fourth teeth from the angle, in profile, the flattened thin-wing extension of the base shown.  $\times 212$ .

Figs. 8-11. *Cratena virens* MacFarland, new species

(Pages 344-347)

- Fig. 8. Right mandible, very thin and delicate.  $\times 50$ .  
Fig. 9. Teeth from masticatory margin, figure shows but a fragment.  $\times 650$ .  
Fig. 10. Two teeth in profile view.  $\times 530$ .  
Fig. 11. Oblique view from above of one of the oldest teeth.  $\times 530$ .

Figs. 12-17. *Cratena spadix* MacFarland, new species

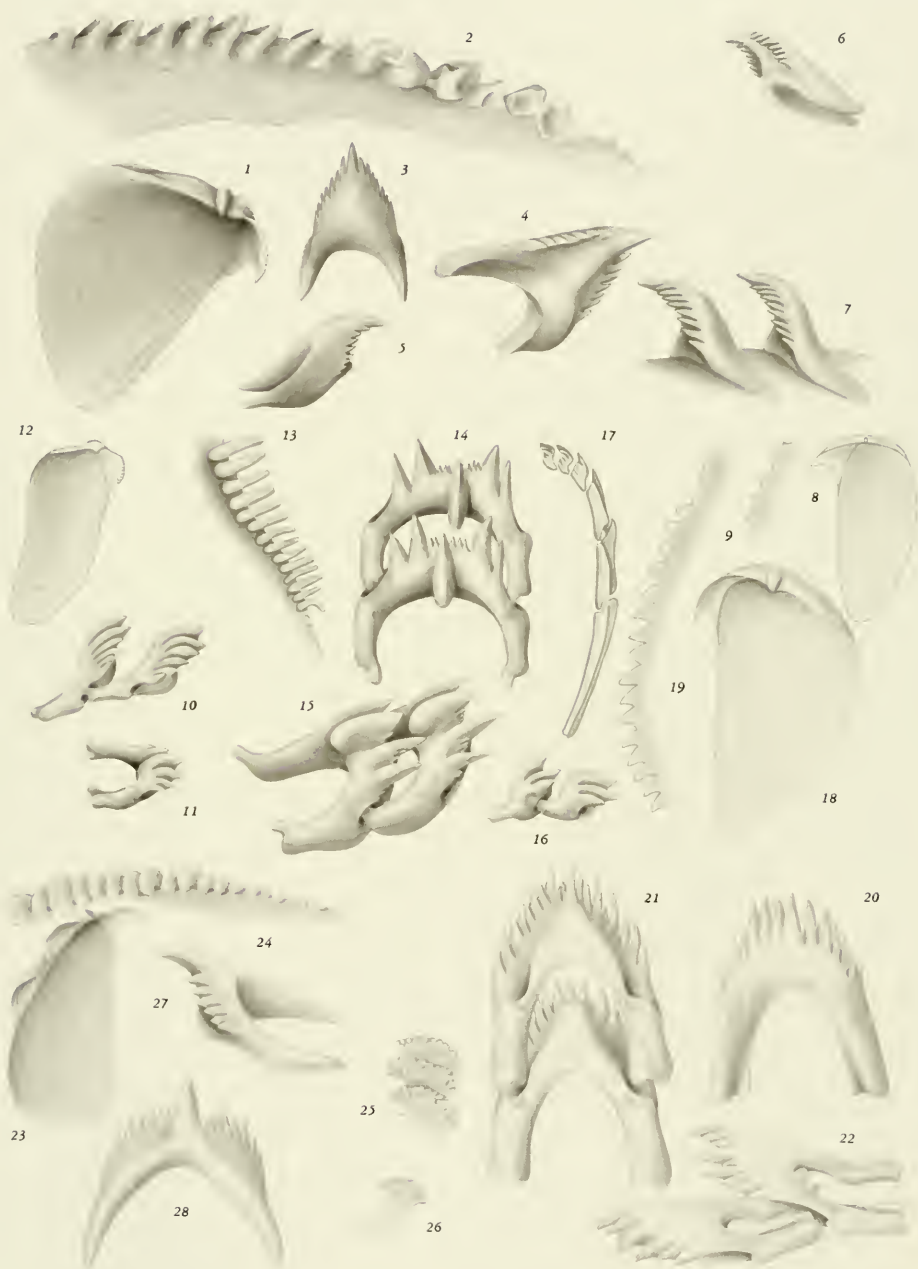
(Pages 351-354)

- Fig. 12. Inner surface of left mandible.  $\times 45$ .  
Fig. 13. Masticatory margin. Teeth in the form of rod-like thickenings projecting as blunt closely set rodlets. Bases overlap the front edge of the margin increasingly from the hinge to the lower edge of the process.  $\times 650$ .  
Fig. 14. Dorsal view of fourth and fifth tooth within the matrix; median spine very prominent, inner end enlarged and knob-like. Minute secondary denticles, seen from above, between the median cusp and first denticle; lateral to these are strong denticles projecting well beyond the median cusp.  $\times 530$ .  
Fig. 15. Two teeth, sixth and seventh from the angle, seen obliquely; knob-like process articulates in the pocket of the preceding tooth; median denticle rises as a ridge.  $\times 530$ .  
Fig. 16. Fortieth and 41st at the posterior bend of the radula.  $\times 530$ .  
Fig. 17. Oldest tip of the radula. This is coiled back upon itself and tapers down to a thread-like tip with three rod-like segments.  $\times 530$ .

Figs. 18-22. *Cratena abronia* MacFarland, new species

(Pages 347-351)

- Fig. 18. Mandible, inner surface.  $\times 50$ .  
Fig. 19. Masticatory process of mandibular margin with well developed pointed denticles.  $\times 650$ .  
Fig. 20. Dorsal surface of 11th tooth. All teeth are exceedingly small and are highly magnified; denticles very irregular.  $\times 530$ .  
Fig. 21. Ventral surface of eighth and ninth teeth, next to the angle.  $\times 530$ .  
Fig. 22. Two teeth in profile, fifth and sixth at the angle; inner margin with a thin, plate-like extension which articulates with the succeeding tooth, variant of the knob of the other cratenas.  $\times 530$ .







Figs. 23-28. **Fiona pinnata** (Eschscholtz)  
(Pages 355-358)

- Fig. 23. Mandible inner face.  $\times 20$ .  
Fig. 24. Outer face of the masticatory margin.  $\times 280$ .  
Fig. 25. Three denticles from the margin, surface minutely roughened.  $\times 530$ .  
Fig. 26. Section through the margin, surface showing one denticle.  $\times 280$ .  
Fig. 27. Oblique view of tooth seen from above.  $\times 180$ .  
Fig. 28. Dorsal view of fourth tooth, from the angle.  $\times 180$ .

## PLATE 69

Figs. 1, 1a. **Cratena rutila** MacFarland, new species  
(Pages 332-336)

- Fig. 1. Reproductive system. The mucous and albumen glands in place; other parts slightly separated; vas deferens very narrow throughout its extent, the prostate segment lacking; large accessory gland present; vagina with spermatheca at its proximal end; vestibule contains female genital openings; penis armed by a terminal chitinous tube.  $\times 43$ .  
Fig. 1a. Detailed drawing to show the relation of the chitinous tip to the cells of the preputium.  $\times 212$ .

Figs. 2, 2a. **Cratena flavovulta** MacFarland, new species  
(Pages 336-337)

- Fig. 2. Reproductive system with the gland mass removed; glans penis long, curved in the preputium at its base, the deferent canal joined by the accessory gland duct.  $\times 43$ .  
Fig. 2a. Chitinous tip of glans under high magnification.  $\times 212$ .

Figs. 3, 3a. **Cratena fulgens** MacFarland, new species  
(Pages 337-340)

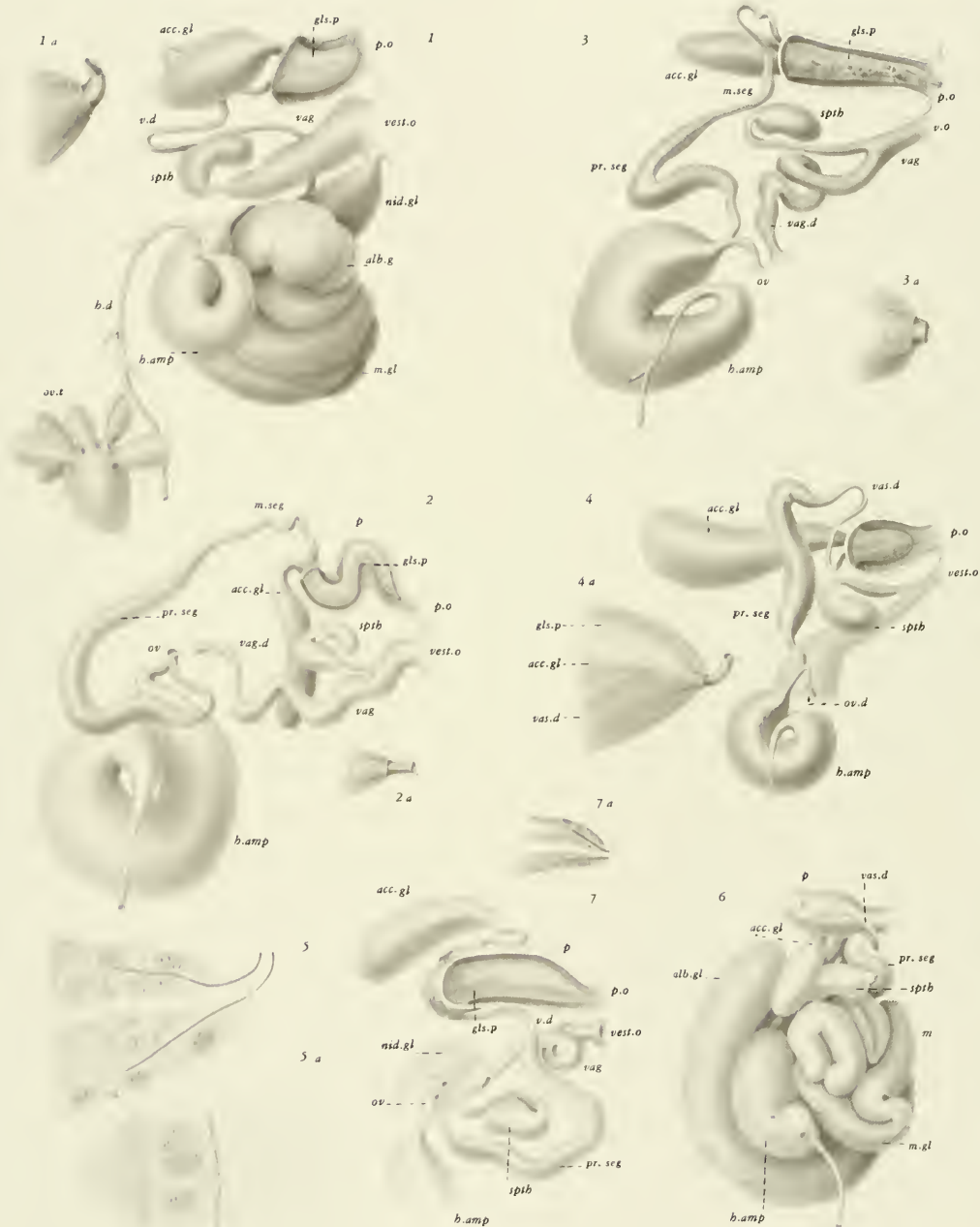
- Fig. 3. Reproductive system. Mucous and albumen glands not shown. The nidamental gland indicated at the point of the opening of the oviduct and emergence of the vagina; distal end of the accessory prostate pushed into the glans where the two ducts are interwoven, uniting near the external opening.  $\times 43$ .  
Fig. 3a. Detail of armature of the glans penis.  $\times 212$ .

Figs. 4-5a. **Cratena albocrusta** MacFarland, new species  
(Pages 340-344)

- Fig. 4. Reproductive system. Prostatic segment long, muscular segment enters the glans penis; large accessory prostate present; nidamental gland opening and that of the vagina merge in the vestibulum.  $\times 43$ .  
Fig. 4a. The union of the accessory duct with that of the vas deferens is near the external opening, where there is a narrow chitinous tip.  $\times 212$ .  
Fig. 5. Detailed figure of the external end of the preputium to show the relations of the external epithelium, chitinous wall extending between these cells and the inner epithelium of the deferent duct.  $\times 582$ .  
Fig. 5a. Cells from the ciliated epithelium near the outer opening of the preputium. cilia very long.  $\times 582$ .

Figs. 6-7a. **Cratena spadix** MacFarland, new species  
(Pages 351-354)

- Fig. 6. Reproductive system as it appears from above before dissection.  $\times 40$ .  
Fig. 7. Albumen and mucous glands removed, remaining parts separated to show clearly their relationships.  $\times 40$ .  
Fig. 7a. Detailed drawing of the very small tip of glans, the chitinous tube does not extend beyond the end as it does in the other species described.  $\times 312$ .



## PLATE 70

Figs. 1-5. **Cratena abronia** MacFarland, new species  
(Pages 347-351)

- Fig. 1. Reproductive system. Anterior complex, with large glands removed; prostate segment and accessory gland of the vas deferens large, vagina short.  $\times 43$ .  
Fig. 2. Detail of the glans armature.  $\times 212$ .  
Fig. 3. Cross section of the glans armature, made at the base of the funnel tube.  $\times 386$ .  
Fig. 4. Cells from the wall of the prostate segment of the vas deferens; base of cells striated, distal part glandular.  $\times 650$ .  
Fig. 5. Cells from the accessory gland, large nuclei.  $\times 650$ .

Figs. 6-8. **Cratena virens** MacFarland, new species  
(Pages 344-347)

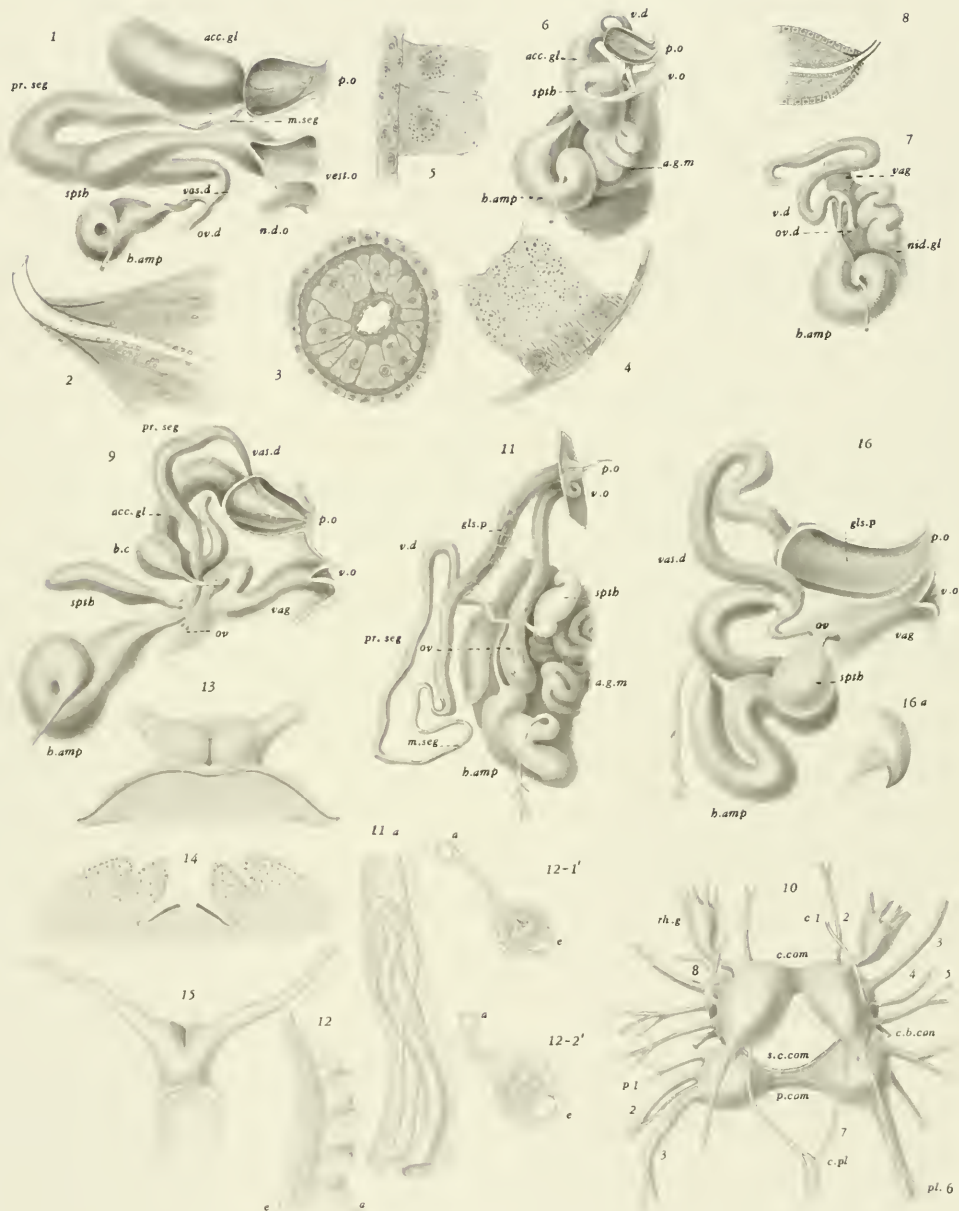
- Fig. 6. Reproductive system as seen from above, parts in place.  $\times 43$ .  
Fig. 7. Part of the complex which shows clearly the division of the distal ampulla into vas deferens and oviduct, the latter entering the nidamental gland; the vaginal duct emerging from it.  $\times 43$ .  
Fig. 8. Detail of the chitinous tip at the external opening of the preputium.  $\times 212$ .

Figs. 9, 10. **Cuthona rosea** MacFarland, new species  
(Pages 326-332)

- Fig. 9. The hermaphroditic ampulla bifurcates. At once the nidamental gland receives the oviduct; the vas deferens enters its glandular segment, reaching the base of the preputial sac and entering the glans penis. This is a short broad cone. The accessory penial gland, long and bent, projects its distal end into the glans penis, giving off a short duct which merges with the deferent duct near the tip, at the external opening. The oviduct has entered the fertilization chamber; near the same point, appears the slender duct of the spermatheca. The vagina, a broad duct arising from the glands complex, receives the bursa copulatrix and reaches the crescentic opening in the female vestibule.  $\times 13$ .  
Fig. 10. Central nervous system. Parts with the usual designations. A nerve, No. 7, arises from cerebro-pleural ganglia median to the origin of No. 6.  $\times 30$ .

Figs. 11 to 12-2' **Fiona pinnata** (Eschscholtz)  
(Pages 355-358)

- Fig. 11. Anterior genital complex as seen from above, parts in position except the long loop of the vas deferens, thrown to the left. The long slender oviduct describes two loops beneath the thin-walled female channel into which it opens; the distant ampulla becomes a narrow long duct before its division.  $\times 12.5$ .  
Fig. 11a. An enlargement of the preputium with the dorsal wall removed, showing the complicated windings of the very long glans penis.  $\times 38.5$ .  
Fig. 12. Drawing made from a transparent mount of whole papillae, showing the parts. An indication of the hepatic channel, the efferent vein, *e*, seen in the stalk; the sinuous longitudinal expansion on the inner margin with its afferent vein, *a*, on the outer border; cross channels passing inward, clearly seen on the thin expansion, thrown into folds. These seem often to form closed loops and again disappear in the tissue of the hepatic channel.  $\times 14$ .  
Fig. 12-1' Drawings made from serial sections; these pass through the stalk and the membranous expansion of a papilla on the inner margin. The outer edge contains a blood vessel, com-







municating with the surface by a series of net-like ridges. These are afferent veins, *a*, returning the blood from the papillae to the heart.  $\times 30$ .

- Fig. 12-2'. An entire papilla is shown, along the outside of which, close to the stalk, is a broad blood vessel. This is the efferent, *e*, vein which carries blood from the heart and connects with the afferent one on the inner membranous margin by cross channels.  $\times 30$ .

Figs. 13, 14. ***Hermisenda crassicornis*** (Eschscholtz)

(Pages 358-365)

- Fig. 13. Ventral view of head region; mouth with thickened lips and lateral rounded thickenings, anterior margin of head a thickened ridge, margin of foot bilabiate, its full width.  $\times 3$ .  
Fig. 14. Outline of section across mouth parts; mandibles below within, lips thick, outer lateral thickenings retracted.  $\times 7.5$ .

Figs. 15-16a. ***Phidiana nigra*** MacFarland, new species

(Pages 366-370)

- Fig. 15. Ventral view, head region; mouth at anterior edge, foot very narrow.  $\times 3.5$ .  
Fig. 16. Anterior genital complex, mucous gland removed. A spherical spermatheca opens into vagina by a short duct.  $\times 7$ .  
Fig. 16a. Black hook which arms the glans penis, characteristic of the genus.  $\times 43$ .

## PLATE 71

Figs. 1-14. *Hermisenda crassicornis* (Eschscholtz)

(Pages 358-365)

- Fig. 1. Mandible. Concave inner surface, hinge thickened, margin above reflected, masticatory process well developed; 50 strong teeth, worn near the hinge, increasing in size as the center is reached, becoming rounded with serrula on the inner face; flattened and widened on the lower margin with serrula on the edge of the outer face.  $\times 7.8$ .
- Fig. 2. Three teeth, 21st, 22nd, 23rd from the inner face of the masticatory process near the center of the margin; inner face of each tooth rounded, with the minute serrula borne in a row near the center.  $\times 212$ .
- Fig. 3. Two denticular teeth from the outer margin of the process near the tip. These are flattened and widened with serrula on the outer edge.  $\times 212$ .
- Fig. 4. Radula, uniserial, 22 to 26 teeth. Figure shows two teeth in profile, median cusp, lateral denticles.  $\times 47$ .
- Fig. 5. Single tooth in side view which shows the lanceolate, pointed denticles; central cusp curving downward to the posterior margin of the base.  $\times 47$ .
- Fig. 6. Detailed figure of the median cusp, flattened above, minute serrulations on the inferior margin.  $\times 105$ .
- Fig. 7. Ventral surface of the 20th tooth near the angle; horseshoe-shaped base, serrula under the median cusp, lateral denticles, all in view.  $\times 47$ .
- Fig. 8. Detailed drawing of the lateral denticles. Series of small ones on the upper margin, long pointed spines below; longest .096 mm.  $\times 105$ .
- Fig. 9. Anterior genital complex, dorsal view. Division of hermaphroditic ampulla into oviduct and vas deferens seen in central position of the figure; prostatic segment enters the preputium, which has its external opening above the vestibule of vagina and accessory glands. Retractor muscle indicated, attached to the proximal end of the preputium.  $\times 10$ .
- Fig. 10. Ventral view of complex. Some parts more clearly seen; external openings hidden.  $\times 10$ .
- Fig. 11. Camera-lucida drawing from dissection of alcoholic specimen; dorsal wall of preputium removed; within the glans a band of conical tuberosities; midway back, a wing-like elevation; distal of this zone the surface is thickly set with minute villousities; external opening subterminal. Female genital openings lie posterior.  $\times 5.5$ .
- Fig. 12. Everted penis, somewhat inflated, seen in profile. Band of tuberosities, villousities, triangular wing all shown.  $\times 10$ .
- Fig. 13. Looking into the opening of the glans from below, wing-like projection extends beyond.  $\times 10$ .
- Fig. 14. Central nervous system. Dorsal view, rhinophore ganglia very prominent, pedal, parapedal, sub-cerebral commissures are membranous in the same wide sheath and relatively long; the pleural commissures long, the two arising from the ventral side form a union from which nerves pass backward. Slender nerves, *a*, *b*, *c*, arise from the anterior margin of the pedal ganglia.  $\times 16.5$ .

Figs. 15-20. *Phidiana nigra* MacFarland, new species

(Pages 366-370)

- Fig. 15. Mandible oval in outline with a strong hinge. Masticatory process armed with about 25 irregular blunt denticles which interlock when closed.  $\times 7$ .
- Fig. 16. Masticatory margin, young end curving to the hinge; denticles blunt and irregular.  $\times 70$ .
- Fig. 17. Thirteenth tooth in profile.  $\times 64$ .
- Fig. 18. Oblique view of median tooth from above, showing the triangular cusp with its lateral denticles, large on the lower margin, small on the cusp.  $\times 64$ .
- Fig. 19. Ventral surface of tooth from the central part of the radula. Thickened under portion of the cusp curves down to the central line of the base which shows a notch on the curved, central, anterior margin.  $\times 64$ .
- Fig. 20. Detail of denticles on the upper margin which are narrowed and project laterally from the point of the cusp.  $\times 180$ .

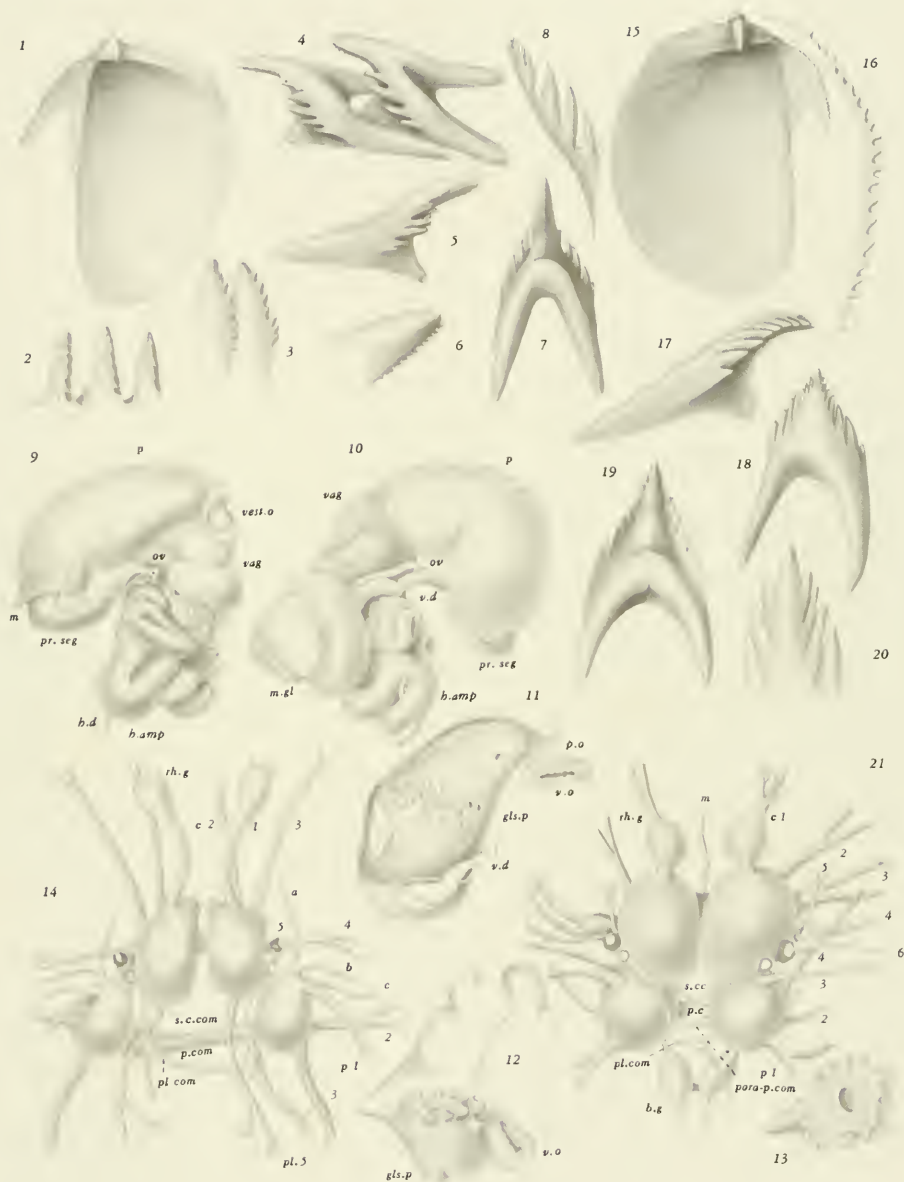




Fig. 21. **Cratena rutila** MacFarland, new species

(Pages 332-336)

- Fig. 21. Central nervous system; exceedingly small, from a small acolid. Anterior cerebral commissures wide with a median nerve passing forward; sub-cerebral commissure, slender and short; pedal one prominent; parapedal very short and slender; pleural commissure from the ventral surface forms a loop sending a nerve backward.  $\times 76$ .



## PLATE 72

Figs. 1-8. *Aeolidia papillosa herculea* Bergh

(Pages 370-373)

- Fig. 1. Mandibles. Innerface of the right mandible, hinge region thick and strong, wing of process curved from hinge, concave below with a gentle slope upward to the dorsal margin.  $\times 10.4$ .
- Fig. 2. Outer face of the right mandible, convex masticatory process strong, free at the tip, margin smooth.  $\times 10.4$ .
- Fig. 3. Double mandibles as seen from above, hinges in contact, wings of the curved masticatory process attached on the anterior ventral margin.  $\times 10.4$ .
- Fig. 4. Detail of the hinge region from the inner face of the right mandible; clearly shown is the distinct cleft which terminates in a notch on the anterior margin, and the hinge thickening at the summit of the pyramidal elevation.  $\times 26$ .
- Fig. 5. Radula. A simple series of pectinate arched teeth, curved forward, bearing a series of stout, regular, lanceolate-tipped denticles, 38 to 43 in number. The figure shows the sixth and seventh teeth in position.  $\times 134$ .
- Fig. 6. The sixth tooth flattened to show the full curve; base widest, and denticles longest at the center of the curve, both decreasing on the sides to the tip.  $\times 134$ .
- Fig. 7. Oldest tooth viewed from above.  $\times 134$ .
- Fig. 8. Section cut longitudinally through the pharyngeal bulb and radula, passing through the 11th and 12th teeth, there being 26 in all. The cuticle, muscle, and epithelium are all represented.  $\times 134$ .

Figs. 9-14. *Aeolidiella oliviae* MacFarland, new species

(Pages 373-377)

- Fig. 9. Left mandible; head thick and strong, deep yellow, the remainder very thin and delicate, concave along the ventral edge, becoming slightly convex in the center and on the outer margin of the dorsal edge. The curved masticatory process wide and long.  $\times 28$ .
- Fig. 10. Both mandibles are shown; the head of each thickened into a pyramidal mass, the apex forming the articulation surface; below is the winged masticatory process bearing a smooth margin. The space, between the upper inner faces of the thickened pyramids, is filled by a very strong transverse muscle.  $\times 27.5$ .
- Fig. 11. Detail of hinge of left mandible which has a single ridge lengthwise of the center.  $\times 105$ .
- Fig. 12. Detail of the right hinge. A deep groove runs the full length of the center, into this the ridge of the opposite hinge fits.  $\times 105$ .
- Fig. 13. Radula. Uniserial with 24 teeth, pectiniform, strongly arched, bearing closely set, narrow, pointed denticles. The median one-half to one-third the length of the others but broader, forming a short triangle in outline, directed upward and backward. The 23rd tooth bears 60 denticles which lengthen rapidly from the center so the whole tooth is emarginate.  $\times 170$ .
- Fig. 14. The first and oldest tooth. This has 40 denticles. The median one short and broadened, adjacent ones shorter but lengthening on the curve. Base narrowest in the median line, wider at the ends of the arc, a condition the reverse of that in *Spurilla braziliiana*.  $\times 170$ .





## INDEX

(New names in **boldface** type)

- Abietinaria, 291  
**abronia**, Cratena, **347**; pls. 59, 68, 70  
 Acanthodoris, 118  
     brunnea, **118**; pl. 20  
     columbina, **121**, 123; pl. 32  
     lutea, **120**, 121; pl. 32  
     nanaimoensis, 123  
 Acarnus erithacus, 168  
 Aclesia, **27**, 28, 30  
     freeri, 30  
     **rickettsi**, **27**; pls. 6, 8, 9  
 Acoela, 56  
 Actaeon, 67  
 (Actinocyclus?) sandiegensis, Doris, 190  
 Aegires, 101  
     albopunctatus, **101**, 103; pls. 18, 31  
     punctilucens, 101  
 Aeolia, **370**, 374  
     herculea, 370  
     papillosa, 370  
     papillosa **herculea**, **370**; pl. 72  
 Aeolidiacea, 295  
 Aeolidiella, 373  
     **oliviae**, **373**; pls. 62, 72  
 Aeolidiidae, 358  
 Aeolidiinae, 370  
 Aeolis (Flabellina?) opalescens, 358  
     (Phidiana?) iodinea, 308  
 agassizii, Dolabella, 17, 35, 142, 154  
 Aglaja, 6  
     diomedea, **6**, 7; pls. 2, 6, 7  
     tricolorata, 6  
 Aglajidae, 6  
 Aglaophenia, 291  
**alboecrasta**, Cratena, **340**; pls. 61, 67, 69  
 albolineata, Dirona, **298**; pls. 30, 56, 63, 64  
 albopunctata, Dendrodoris, **196**; pl. 28  
     Doriopsilla, 196  
     Doris, 196  
 albopunctatus, Aegires, **101**; 103; pls. 18, 31  
**albus**, Dendronotus, 256, 272, 274, **275**, 279; pls.  
     40, 46, 47, 48, 49, 50, 51  
 Aldisa, **169**, 170  
     sanguinea, **169**; pls. 25, 29, 35  
     zetlandica, 170  
 Aldisinae, 165  
     amethystina, Renilla, 203  
 Amphitrite, 254  
     frondosa, 207, 254  
     frondosus, 256  
 Amphitritidea, 254  
 Amphitritidia, 254  
 Anaspidea, 12  
 Ancula, 123  
     pacifica, **123**; pls. 21, 29  
 Anisodoris, 173, 177, 179, **188**  
     nobilis, **188**; pls. 28, 29, 37  
 antarctica, Austrodoris, 172  
 antarctica?, Austrodoris, 173  
 Antiopa, 302  
     splendida, 302  
 Antiopella, 302  
     **aureocincta**, **303**; pls. 57, 63, 64  
 aperta, Bulla, 1  
 apiculata, Doto, 290  
 Aplysia, **12**, 15, 17, 27, 66, 67  
     californica, **12**, 14, 15, 16; pls. 3, 6, 8, 9  
     punctata, 16  
     ritteri, 16  
 Aplysiidae, 12  
 arborescens, Dendronotus, 254, 255, 256, 264  
     Doris, 254, 256  
     Tritonia, 254  
 arbutus, Doris, 168  
     Rostanga, 166, 168  
 Archidoriinae, 181  
 Archidoris, 172, 173, 179, **181**  
     montereyensis, **181**, 182, 189, 190; pls. 27, 37  
     nyctea, 182  
     tuberculata, 182  
 Armina, **197**, 198  
     californica, **198**, 205, 206; pls. 38, 43, 44  
     columbiana, 206  
     maculata, 197, 198  
     tigrina, 197, 198  
     vancouverensis, 206  
 Arminacea, 197  
 Arminidae, 197  
 (Asteronotus) sanguinea, Doris, 169  
 Asteronotus, 170  
     (?) sanguineus, 169  
 Astrodoris, 171

- atra, Polycera, **115**, 117, 118; pls. 18, 31  
 aurantiaca, Triopha, 115  
 aurantiacus, Pleurobranchus, 70  
**aureocincta**, Antiopella, **303**; pls. 57, 63, 64  
 australis, Austroductor, 172  
     Janolus, 304, 306  
 Austroductor, **171**, 172, 179  
     antarctica, 172  
     antarctica?, 173  
     australis, 172  
     crenulata, 172  
     falklandica, 172  
     fulva, 172  
     granulatissima, 173  
     keruelensis, 172  
     mcmurdensis, 172  
     michaelseni, 172  
     nivium, 172  
     **odhneri**, 172, **173**; pls. 26, 29, 36  
     peculiaris, 173  
     rubescens, 172  
     tomentosa, 172  
 ?Austroductor violacea, 173  
  
 bakeri, Philine, **1**; pl. 7  
 Barnardaclesia, 31, 32  
**bedeckta**, Elysia, **50**, 52; pls. 4, 10  
 belli, Tritoniella, 224  
 berghii, Marionia, 233  
 Berthella, **69**, 79  
     brocki, 74, 93  
     gotoi, 71  
     plumula, 70, 71  
     porosa, 69  
     sideralis, **69**; pl. 13  
 Berthellina, **70**, 71  
     borneensis, 71  
     engeli, **70**, 71, 74, 75; pls. 13, 16  
 (Berthellina) brocki, 74  
 bifida, Doris, 38  
 blainvillea, Marionia, 233  
**bolini**, Corambella, 133, **134**, 136, 139; pls. 22, 29, 32  
 borneensis, Berthellina, 71  
 Bornellopsis, 288, 290  
     kabretiana, 290  
 Bouvieria, 79  
     digueti, 75  
     ocellata, 74  
     perforata, 74  
     sideralis, 69  
     braziliana, Spurilla, 375  
     brocki, Berthella, 74, 93  
         (Berthellina), 74  
     brockii, Pleurobranchaea, 98  
     brucei, Tritoniopsilla, 218  
     brunnea, Acanthodoris, **118**; pl. 20  
 Bryopsis, 41, 42, 53, 54  
     corticulans, 42, 54  
 Bryozoa, 20, 21  
 Bugula, 118  
 Bulla, 11  
     aperta, 1  
 Bursatella, 31, 32  
     savignana, 27  
  
 Cadlina, **140**, 142, 145, 148, 149, 150, 151  
     flavomaculata, 140, 143, **144**, 148, 150, 151, 152; pls. 23, 29, 33  
     japonica, 151, 152  
     laevis, 140  
     **luteomarginata**, **140**, 150, 151, 152, 154, 159; pls. 23, 29, 33  
     marginata, 140  
     **modesta**, 140, 143, **147**, 151, 152; pls. 30, 33  
     pacifica, 140, 151, 152  
     sagamiensis, 151, 152  
     calensis, Chromodoris, 157  
 californica, Aplysia, **12**, 14, 15, 16; pls. 3, 6, 8, 9  
     Armina, **198**, 205, 206; pls. 38, 43, 44  
     Coryphella, 320  
     Dolabella, **32**, 35, 36; pls. 6, 8, 9  
     Hancockia, 245, **246**, 248; pls. 38, 43, 49, 50, 52, 53  
**californica**, Pleurobranchaea, **94**, 95, 101; pls. 15, 17  
 californica, Pleurophyllidia, 198, 205  
 californicus, Pleurobranchus, 74, **82**, 83, 87, 88; pls. 6, 13  
     **denticulatus**, Pleurobranchus, **84**, 88; pls. 5, 13, 16  
 californiensis, Chromodoris, 154, **157**, 163, 164; pls. 24, 34  
     Glossodoris, 157  
 callosa, Dolabella, 32  
 canaliculata, Gigartina, 321  
 carpenteri, Triopa, 106, 109  
     Triopha, **106**, 109, 115; pls. 19, 29, 31  
 Catronia, 332

- Cavolina, 358, 366  
     crassicornis, 358  
 Cephalaspidea, 1  
 cervina, Tyrodina, 63, 64  
 chacci, Pleurobranchus, 84  
 Chioraera, **280**, 283, 286  
     dalli, 280, 285, 287  
     leonina, **280**, 285, 287; pls. 41, 54  
 Chromodoris, 140, 142, 153, **157**, 163  
     calensis, 157  
     californiensis, 154, **157**, 163, 164; pls. 24, 34  
     dalli, 154  
     macfarlandi, 153  
     mcfarlandi, 158  
     porterae, **163**, 165; pls. 24, 34  
     universitatis, 158, 163  
 citrina, Tyrodina, 62, 65, 67, 68  
 clavigera, Doris, 207  
     Tritonia, 207  
 coccinea, Rostanga, 167, 187  
 cockerelli, Laila, **104**; pls. 20, 29, 31  
 Codium, 41, 42, 52, 54  
 columbiana, Armina, 206  
     Doto, **288**, 295  
 columbina, Acanthodoris, **121**, 123; pl. 32  
 Corambe, **129**, 130, 132, 133, 134, 136  
     pacificae, **130**, 132, 134, 135, 136, 137, 138,  
     139; pls. 22, 29, 32  
     sargassicola, 133, 135, 136, 137  
     testudinaria, 132, 137, 138  
 Corambella, **132**, 133, 136  
     bolini, 133, **134**, 136, 139; pls. 22, 29, 32  
     depressa, 133  
 Corambidae, 129  
 cornaliae, Doto, 289  
 coronata, Doris, 288, 289, 292, 294  
 corticulans, Bryopsis, 42, 54  
 Coryphella, **313**, 322  
     californica, 320  
     fisheri, **318**, 320, 222; pls. 58, 65, 66  
     pricei, **313**, 316, 322; pls. 58, 65, 66  
 crassicornis, Cavolina, 358  
     Hermisenda, **358**, 359, 362, 363, 368; pls.  
     55, 70, 71  
 Cratena, **332**  
     abronia, **347**; pls. 59, 68, 70  
     albocrusta, **340**; pls. 61, 67, 69  
     flavovulta, **336**; pls. 60, 67, 69  
     fulgens, **337**; pls. 60, 67, 69  
     rutila, **332**; pls. 60, 67, 69, 71  
     spadix, **351**; pls. 60, 68, 69  
     virens, **344**; pls. 61, 68, 70  
 crenulata, Austrodoris, 172  
 cristatus, Janus, 307  
 Ctenodoris, 194  
 Cuthona, **326**  
     rosea, **326**; pls. 59, 68, 70  
 Cuthonella, 250  
 Cuthonidae, 326  
 Cystoseira, 265, 272  
     osmundacea, 325, 328  
 dalli, Chioraera, 280, 285, 287  
     Chromodoris, 154  
     Dendronotus, **255**, 256, 257  
     Dendronotus frondosus, 255  
 Delesseria, 253  
 delicatus, Pleurobranchus, 71  
 Dendrodoris, **193**, 194  
     albopunctata, **196**; pl. 28  
     fulva, **194**, 195; pls. 28, 29  
     lugubris, 193  
 Dendrodoridinae, 193  
 Dendronotacea, 206  
 Dendronotidae, 254  
 Dendronotus, **254**, 258, 262, 265, 269, 272, 279  
     albus, 256, 272, 274, **275**, 279; pls. 40, 46,  
     47, 48, 49, 50, 51  
     arborescens, 254, 255, 256, 257, 264  
     dalli, **255**, 256, 257  
     elegans, 254  
     frondosus, 254, 255, **256**, 257, 264, 265,  
     279  
     frondosus dalli, 255  
     frondosus purpureus, 255  
     frondosus rufus, 255  
     giganteus, **255**, 257, 258  
     iris, 254, 255, 256, **257**, 260, 274, 279; pls.  
     47, 48, 49, 50, 51  
     nuber, 256  
     purpureus, **254**, 256, 257  
     rufus, **255**, 256, 257  
     subramosus, 255, **265**, 272, 274, 279; pls.  
     40, 46, 47, 49, 50, 52  
     venustus, 255, **271**, 272, 279; pls. 40, 46,  
     47, 49, 50, 52  
 denticulatus, Pleurobranchus californicus, **84**, 88;  
     pls. 5, 13, 16  
 depilans, Tethys, 12



- depressa, Corambella, 133  
 Diaulula, **190**, 196  
     sandiegensis, **190**; pls. 27, 29, 30, 35  
 digueti, Bouvieria, 75  
     Pleurobranchus, **75**, 79, 82, 87; pls. 14, 16  
 diomedea, Aglaja, **6**, 7; pls. 2, 6, 7  
     Duvaucelia, 242, 243  
     Tridachia, 54  
     Tridachia (Tridachiella), 54  
     Tridachiella, 54  
 Diomedea, Tridachia, 54  
 diomedium, Doridium, 6  
 Diphyllidia, 197, 198  
 Diptera, 302  
 Dirona, **295**, 296  
     albolineata, **298**; pls. 30, 56, 63, 64  
     picta, **295**, **296**, 299; pls. 56, 63, 64  
 Dironidae, 295  
 Discodoridae, 188  
 Discodoris, 192  
     heathi, **192**; pls. 27, 35  
 Dolabella, **32**, 79  
     agassizii, 17, 35, 142, 154  
     californica, **32**, 35, 36; pls. 6, 8, 9  
     callosa, 32  
 Dolabellinae, 32  
 Doridacea, 101  
 Doridella obscura, 133  
 Dorididae, 140  
 Doridium diomedium, 6  
 Doridopsis, 193, 194  
     gemmacea, 194  
     reticulata, 196  
 Doriopsilla albopunctata, 196  
     reticulata, 196  
 Doriopsis, 193, 194  
     fulva, 194  
     granulosa, 194  
 Doris, **179**, 207  
     (Actinocyclus?) sandiegensis, 190  
     albopunctata, 196  
     arborescens, 254, 256  
     arbutus, 168  
     (Asteronotus) sanguinea, 169  
     bifida, 38  
     clavigera, 207  
     coronata, 288  
     laevis, 140  
     maculata, 287, 288  
     marginata, 140  
     montereyensis, 181  
     obvelata, 140  
     papillosa, 370  
     repanda, 140  
     (Staurodoris) verrucosa, 177  
     tetraquetra, 208  
     tuberculata, 182  
     (s.l.) species, **179**, 196; pl. 25  
 Doto, **287**, 288, 290, 293, 295  
     apiculata, 290  
     columbiana, **288**, 295  
     cornaliae, 289  
     coronata, 289, 292, 294  
     fragilis, 289, 290  
     japonica, 290  
     pinnatifida, 290, 292  
     uncinata, 243, 245  
     **varians**, 288, **289**, 294; pls. 42, 44, 48  
 Dotona, 288  
 Dotonidae, 287  
 Drepania, 126, 127, 129  
     fusca, 126, 129  
     graeffei, 129  
     tartanella, 129  
     velox, 127  
 Drepanida, 127, 129  
 Duvaucelia, **207**, 219, 225, 231, 233, 241, 269, 274, 279  
     diomedea, 242, 243  
     exsulans, 212, 223, **226**, 241, 242, 243; pls. 30, 39, 43, 44, 45  
     festiva, 212, **218**, 223, 224, 225, 226, 241, 243; pls. 39, 43, 44, 45  
     **gilberti**, 223, 224, **235**, 241, 242, 243; pls. 30, 43, 44, 45  
     gracilis, 207  
     palmeri, 241  
     tetraquetra, 207, **208**, 213, 214, 223, 241; pls. 30, 39, 43, 44, 45  
 Duvauceliidae, 206  
     elegans, Dendronotus, 254  
     elioti, Triopha, 115  
 Elysia, **50**, 51, 52  
     **bedeckta**, **50**, 52; pls. 4, 10  
     timida, 50  
 Elysiidae, 50  
 engeli, Berthellina, **70**, 71, 74, 75; pls. 13, 16  
 Enteromorpha, 49  
 enteromorpha, Phyllobranchopsis, **46**; pl. 10

- Eolidia pinnata*, 355  
*Eolis nana*, 326  
     *rufibranchialis*, 313  
*erithacus*, *Acanus*, 168  
*Eubbranchus*, **323**  
     *occidentalis*, **323**; pls. 62, 65, 66  
     *tricolor*, 323  
*eudactylota*, *Hancockia*, 243, 244, 245  
*Euplexaura marki*, 216  
*exsulans*, *Duvaucelia*, 212, 223, **226**, 241, 243;  
     pls. 30, 39, 43, 44, 45  
     *Tritonia*, 226, 228  
  
*falklandica*, *Austrodoris*, 172  
*Favorinae*, 358  
*festiva*, *Duvaucelia*, **212**, 218, 223, 224, 225,  
     241, 243; pls. 39, 43, 44, 45  
     *Lateribranchiae*, 218  
     *Tritonia*, 218  
*Fimbria fimbria*, 280  
*fimbria*, *Fimbria*, 280  
     *Tethys*, 280  
*Frimbridae* [Tethyidae], 280  
*Fiona*, 354  
     *marina*, 355  
     *marina pacifica*, 355  
     *pinnata*, **355**; pls. 68, 70  
*Fionidae*, 354  
*fisheri*, *Coryphella*, **318**, 320, 322; pls. 58, 65, 66  
*Flabellina opalescens*, 358  
 (Flabellina?) *opalescens*, *Aeolis*, 358  
*Flabellinidae*, 308  
*Flabellinopsis*, **308**  
     *iodinea*, **308**; pls. 58, 65, 66  
*flavomaculata*, *Cadlina*, 140, 143, **144**, 148, 150,  
     151, 152; pls. 23, 29, 33  
*flavovulta*, *Cratena*, **336**; pls. 60, 67, 69  
*forskali*, *Pleurobranchus*, 89  
*fragilis*, *Doto*, 289, 290  
     *Melibaea*, 288  
*freeri*, *Aclesia*, 30  
*frondosa*, *Amphitrite*, 207, 254  
*frondosus*, *Amphitrite*, 256  
     *dalli*, *Dendronotus*, 255  
     *Dendronotus*, 254, 255, **256**, 257, 264, 265,  
         279  
     *purpureus*, *Dendronotus*, 255  
     *rufus*, *Dendronotus*, 255  
*fulgens*, *Cratena*, **337**; pls. 60, 67, 69  
*Fucus*, 112  
  
*fulva*, *Austrodoris*, 172  
     *Dendrodoris*, **194**, 195; pls. 28, 29  
     *Doriopsis*, 194  
*fungina*, *Tylodina*, **56**, 67, 68; pls. 5, 6, 11, 12,  
     16  
*fusca*, *Drepania*, 126, 129  
     *Trapania*, 129  
  
*Galvina*, **244**  
*Gastropoda*, 1  
*Gastropteridae*, 2  
*Gastropteron*, **2**, 67  
     *meckeli*, 4, 6  
     *pacificum*, **2**, 4, 5; pls. 1, 7  
     *rubrum*, 4  
*Geitodoris patagonica*, 175  
*gemmaeae*, *Doridopsis*, 194  
*gigantea*, *Sphaerostoma*, 208  
     *Tritonia*, 208, 211, 213, 241  
*giganteus*, *Dendronotus*, **255**, 257, 258  
*Gigartina*, 248  
     *canaliculata*, 321  
*gilberti*, *Duvaucelia*, 223, 224, **235**, 241, 242,  
     243; pls. 30, 43, 44, 45  
  
*Glaucus*, 250  
*Glossodoridinae*, 140  
*Glossodoris*, 140, 142, **153**, 157  
     *californiensis*, 157  
     *macfarlandi*, **153**, 159; pls. 22, 34  
*Goniodoridinae*, 123  
*gotoi*, *Berthella*, 71  
*Govia*, 243, 244  
     *rubra*, 243, 244, 245  
     *viridis*, 244, 245  
*gracilis*, *Duvaucelia*, 207  
*graeffe*, *Drepania*, 129  
     *Trapania*, 129  
*grandis*, *Triopha*, **112**, 115; pls. 19, 31  
*granulatissima*, *Austrodoris*, 173  
*granulosa*, *Doriopsis*, 194  
*Guyonia*, 194  
  
*Haminoea*, 11  
*Hancockia*, **243**, 244, 245, 251, 253, 254  
     *californica*, 245, **246**, 248; pls. 38, 43, 49,  
         50, 52, 53  
     *eudactylota*, 243, 244, 245  
     *papillata*, 245  
     *rubra*, 248, 249, 252  
     *uncinata*, 244, 245

- viridis, 248, 249  
Hancockiidae, 243  
Haustellodoris, 194  
heathi, Discodoris, 192; pls. 27, 35  
herculea, Acolidia, 370  
**herculea**, Acolidia papillosa, **370**; pl. 72  
Hermacea, **38**, 43, 46, 47  
    **ornata**, **38**; pls. 4, 10, 30  
Hermacina, **43**, 46  
    maculosa, 43, 48  
    **oliviae**, **43**; pls. 4, 10  
Hermisenda, **358**, 363  
    crassicornis, **358**, 359, 362, 368; pls. 55, 70, 71  
    opalescens, 359  
hilli, Lepas, 356  
hombergii, Tritonia, 207, 216  
Hopkinsia, 125  
    rosacea, **125**; pls. 21, 31  
Hydractinia, 325, 328  
  
Idulia, 288  
Iduliana, 244, 245  
    papillata, 244, 245  
inermis, Navanax, **9**; pls. 2, 6, 7  
    Strategus, 9  
iodinea, Flabellinopsis, **308**; pls. 58, 65, 66  
    (Phidiana?) Aeolis, 308  
iris, Dendronotus, 254, 255, 256, **257**, 260, 274, 279; pls. 47, 48, 49, 50, 51  
  
Janolus australis, 304, 306  
Janthina, 355  
Janus cristatus, 307  
japonica, Cadlina, 151, 152  
    Doto, 290  
    Reniera, 168  
    Trapania, 129  
  
kabretiana, Bornellopsis, 290  
karykinos, Plocamia, 168  
kerguelensis, Austrodoris, 172  
  
laevis, Cadlina, 140  
    Doris, 140  
lafonti, Phyllaplysia, 19  
Laila, 103  
    cockerelli, **104**; pls. 20, 29, 31  
Laminaria, 112, 253  
  
Lateribranchiaca, 218  
    festiva, 218  
leonina, Chioraera, **280**, 285, 287; pls. 41, 54  
Lepas hilli, 356  
Limax marinus, 355  
    papillosus, 370  
    tetraquetra, 207, 208  
lineata, Pleurophyllidia, 205  
Linguella, 197  
lithophoena, Plocamia, 168  
luetkeana, Nereocystis, 132, 136  
lugubris, Dendrodoris, 193  
lutea, Acanthodoris, **120**, 121; pl. 32  
**luteomarginata**, Cadlina, **140**, 150, 151, 152, 154, 159; pls. 23, 29, 33  
  
macfarlandi, Chromodoris, 153  
    Glossodoris, **153**, 159; pls. 22, 34  
Macrocystis, 115, 267, 272, 321  
    pyrifer, 132, 136  
maculata, Armina, 197, 198  
    Doris, 287, 288  
    Triopha, **109**, 115; pls. 19, 31  
maculosa, Hermacina, 43, 48  
marginata, Cadlina, 140  
    Doris, 140  
marina, Fiona, 355  
    pacifica, Fiona, 355  
    Zostera, 132  
Marionia, 215, 216, 218, 223, 225, 232, 233, 269  
    berghii, 233  
    blainvillea, 233  
    quadrilatera, 225  
marinus, Limax, 355  
Marionopsis, 218  
marki, Euplexaura, 216  
mcfarlandi, Chromodoris, 158  
mc-murdensis, Austrodoris, 172  
meckeli, Gastroperon, 4, 6  
meckelii, Pleurobranchaea, 94, 98, 99, 100, 101  
Melibaea fragilis, 288  
Melibe, 280  
    pellucida, 280  
    rosea, 280  
membranacea, Membranipora, 134, 136  
Membranipora, 131, 135  
    membranacea, 134, 136  
    villosa, 132

- michaelsoni, Austrodoris, 172  
 Miranda, 123  
**modesta**, Cadlina, 140, 143, **147**, 151, 152; pls. 30, 33  
     Triopha, 106, 109, 115  
 Montereina, 188  
     nobilis, 188  
 montereysensis, Archidoris, **181**, 182, 189, 190; pls. 27, 37  
     Doris, 181  
 muscula, Rostanga, 165, 168  
  
 nana, Eolis, 326  
 nanaimoensis, Acanthodoris, 123  
 Navanax, 7, **9**, 10, 11  
     inermis, **9**; pls. 2, 6, 7  
 Nereocystis, 115  
     luetkeana, 132, 136  
**nigra**, Phidiana, **366**; pls. 62, 70, 71  
 nivium, Austrodoris, 172  
 nobilis, Anisodoris, **188**; pls. 28, 29, 37  
     Montereina, 188  
     Oithona, 354  
 Notarchus, 27, 28, 31, 33, 34  
 Notaspidea, 56  
 Notodoridae, 101  
 nuber, Dendronotus, 256  
 Nudibranchiata, 101  
 nyctea, Archidoris, 182  
  
 obesa, Pleurobranchaea, 95  
 obscura, Doridella, 133  
 obvelata, Doris, 140  
**occidentalis**, Eubbranchus, **323**; pls. 62, 65, 66  
 ocellata, Bouvieria, 74  
**odhneri**, Austrodoris, 172, **173**; pls. 26, 29, 36  
 Oithona nobilis, 354  
 okadae, Reniera, 168  
**oliviae**, Aeolidiella, **373**; pls. 62, 72  
     Hermaeina, **43**; pls. 4, 10  
 Onchidoridinae, 118  
 opalescens, Flabellina, 358  
     (Flabellina?), Aeolis, 358  
     Hermisenda, 359  
 Ophalitispongia pennata, 168  
 Opisthobranchiata, 1  
**ornata**, Hermaea, **38**; pls. 4, 10, 30  
 Oscaniella, 83  
     [Pleurobranchus] purpurea, 82  
  
 Oscanius, 79  
 osmundacea, Cystoseira, 325, 328  
  
 pacifica, Ancula, **123**; pls. 21, 39  
     Cadlina, 140, 151, 152  
     Corambe, **130**, 132, 134, 135, 136, 137, 138, 139; pls. 22, 29, 32  
     Fiona marina, 355  
 pacificum, Gastropteron, **2**, 4, 5; pls. 1, 7  
 Palio pallida, 118  
 pallida, Palio, 118  
 palmeri, Duvauclia, 241  
 papillata, Hancockia, 245  
     Iduliana, 244, 245  
 papillosa, Aeolidia, 370  
     Doris, 370  
     **herculea**, Aeolidia, **370**; pl. 72  
 papillosus, Limax, 370  
 patagonica, Geitodoris, 175  
 patagonicus, Pleurobranchus, 75  
 peculiaris, Austrodoris, 173  
 pellucida, Melibe, 280  
 pennata, Ophalitispongia, 168  
 perforata, Bouvieria, 74  
 peronii, Pleurobranchus, 75  
 perrieri, Pleurobranchus, 89  
 perspicillata, Rostanga, 167  
 Petelodoris, 182  
     **spongicola**, **183**, 187; pls. 27, 30, 37  
     triphylla, 182, 185  
 Phidiana, **366**, 373  
     **nigra**, **366**; pls. 62, 70, 71  
 (Phidiana?) iodinea, Aeolis, 308  
 Philinacea, 1  
 Philine, **1**, 7  
     bakeri, **1**; pl. 7  
     quadripartita, 1  
     sp., 7  
 Philinidae, 1  
 Philininae, 1  
 Phyllaplysia, **19**, 23, 27  
     lafontii, 19  
     taylori, **19**, 21; pls. 3, 8, 9  
 Phyllobranchopsis, 46  
     enteromorphea, **46**; pl. 10  
 picta, Dirona, 295, **296**, 299; pls. 56, 63, 64  
 pinnata, Eolidia, 355  
     Fiona, **355**; pls. 68, 70  
 pinnatifida, Doto, 290, 292

- plebria, Tritonia, 207  
 Pleurobranchaea, **94**, 98  
     brockii, 98  
     **californica**, **94**, 95, 101; pls. 15, 17  
     meckelii, 94, 98, 99, 100, 101  
     obesa, 95  
 Pleurobranchacinae, 94  
 Pleurobranchidae, 69  
 Pleurobranchinae, 69  
 Pleurobranchus, **75**, 79, 83, 84  
     aurantiacus, 70  
     californicus, 74, **82**, 83, 84, 87, 88; pls. 6, 13  
     californicus **denticulatus**, **84**, 88; pls. 5, 13,  
     16  
     chacei, 84  
     delicatus, 71  
     digueti, **75**, 79, 82, 87; pls. 14, 16  
     forskali, 89  
     patagonicus, 75  
     peronii, 75  
     perrieri, 89  
     plumula, 69, 70, 74, 75  
     sideralis, 69  
     **strongi**, 74, 84, **89**; pls. 6, 15, 16  
     s. str., 89  
 [Pleurobranchus] purpurea, Oscaniella, 82  
 Plocamia karykinos, 168  
     lithophoenia, 168  
 plumula, Berthella, 70, 71  
     Pleurobranchus, 69, 70, 74, 75  
 Pleurophyllidia, 197, 198  
     californica, 198, 205  
     lineata, 205  
     undulata, 197, 198  
     vancouverensis, 205  
 Polycera, **115**, 118, 127  
     atra, **115**, 117, 118; pls. 18, 31  
     quadrilineata, 116, 117  
 Polyceridae, 101  
 Polycerinae, 103  
 porosa, Berthella, 69  
 porterae, Chromodoris, **163**, 165; pls. 24, 34  
 pricei, Coryphella, **313**, 316, 322; pls. 58, 65, 66  
 Pteracolidia, 250  
 pulchra, Rostanga, **165**, 168, 170; pls. 25, 29, 35  
 punctata, Aplysia, 16  
 punctilucens, Aegires, 101  
 punctulata, Tylodina, 56  
 purpurea, Oscaniella [Pleurobranchus]  
     purpureus, Dendronotus, **254**, 256, 257  
     Dendronotus frondosus, 255  
     pustulosa, Pleurophyllidia, 198  
     pyrifer, Macrocyctis, 132, 136  
 quadrilatera, Mariona, 225  
 quadrilineata, Polycera, 116, 117  
 quadripartita, Philine, 1  
 Reniera japonica, 168  
     okadai, 168  
 Renilla amethystina, 203  
 repanda, Doris, 140  
 reticulata, Doridopsis, 196  
     Doriopsilla, 196  
     Tritonia, 218, 226, 241  
**rickettsi**, Aclisia, **27**; pls. 6, 8, 9  
 ritteri, Aplysia, 16  
 rosacea, Hopkinsia, **125**; pls. 21, 31  
**rosea**, Cuthona, **326**; pls. 59, 68, 70  
     Melibe, 280  
 Rostanga, **165**, 168  
     arbutus, 166, 168  
     coccinea, 167, 187  
     muscula, 165, 168  
     perspicillata, 167  
     pulchra, **165**, 168, 170; pls. 25, 29, 35  
 rubescens, Austrodoris, 172  
 rubra, Govia, 243, 244, 245  
     Hancockia, 248, 249, 252  
 rubrum, Gastroteron, 4  
 rufibranchialis, Eolis, 313  
 rufus, Dendronotus, **255**, 256, 257  
     Dendronotus frondosus, 255  
**rutila**, Cratena, **332**; pls. 60, 67, 69, 71  
 Sacoglossa, **38**, 44  
 sagamiensis, Cadlina, 151, 152  
 sandiegensis, (Actinocyclus?) Doris, 190  
     Diaulula, **190**; pls. 27, 29, 30, 35  
 sanguinea, Aldisa, **169**; pls. 25, 29, 35  
     (Asteronotus) Doris, 169  
 (?) sanguineus, Asteronotus, 169  
 sargassicola, Corambe, 133, 135, 136, 137  
 savignana, Bursatella, 27  
 sideralis, Berthella, **69**; pl. 13  
     Bouvieria, 69  
     Pleurobranchus, 69  
 sinuata, Tritoniella, 224

- spadix**, *Cratena*, **351**; pls. 60, 68, 69  
*Sphaerostoma gigantea*, 208  
     *undulata*, 218, 225, 241  
*splendida*, *Antiope*, 302  
**spongiicola**, *Petelodoris*, **183**, 187; pls. 27, 30, 37  
*Spurilla braziliana* 375  
*Staurodoris*, 194  
(*Staurodoris*) *verrucosa*, *Doris*, 177  
*Stiligeridae*, 38  
*Strategus inermis*, 9  
**strongi**, *Pleurobranchus*, 74, 84 **89**; pls. 6, 15, 16  
**subramosus**, *Dendronotus*, 255, **265**, 274, 279; pls. 40, 45, 47, 49, 50, 52  
*Susania*, 79  
     *testudinaria*, 82  
     *testudinaria*, 82
- tartanella*, *Drepania*, 129  
     *Trapania*, 129  
*taylori*, *Phyllaplysia*, **19**, 21; pls. 3, 8, 9  
*Tectibranchiata*, 1  
*testudinaria*, *Susania*, 82  
*testudinaria*, *Corambe*, 132, 137, 138  
     *Susania*, 82  
[Tethyidae], *Fimbriidae*, 280  
*Tethys depilans*, 12  
     *fimbria*, 280  
*tetraquetra*, *Doris*, 208  
     *Duvaucelia*, 207, **208**, 213, 214, 223, 241; pls. 30, 39, 43, 44, 45  
     *Limax*, 207, 208  
     *Tritonia*, 208, 211  
     *Tritoniopsilla*, 208  
*Thecacera velox*, 127, 129  
*Themisto*, 115  
*thiona*, *Verongia*, 61  
*tigrina*, *Armina*, 197, 198  
*timida*, *Elysia*, 50  
*Trapania*, **126**, 127, 129  
     *fusca*, 129  
     *graeffei*, 129  
     *japonica*, 129  
     *tartanella*, 129  
     *velox*, **127**, 129; pls. 20, 32  
*tricolor*, *Eubbranchus*, 323  
*tricolorata*, *Aglaja*, 6  
*Tridachia diomedea*, 54  
     *diomedea*, 54  
     (*Tridachiella*) *diomedea*, 54  
*Tridachiella*, 54  
     *diomedea*, 54  
(*Tridachiella*) *diomedea*, *Tridachia*, 54  
*triegi*, *Tritonia*, 207  
*trinchessii*, *Tylodinella*, 65, 67  
*Triopa*, 106, 207, 218  
     *carpenteri*, 109  
*Triopha*, **106**, 109, 115  
     *aurantiaca*, 115  
     *carpenteri*, **106**, 109, 115; pls. 19, 29, 31  
     *elioti*, 115  
     *grandis*, **112**, 115; pls. 19, 31  
     *maculata*, **109**, 115; pls. 19, 31  
     *modesta*, 106, 109, 115  
*triphylia*, *Petelodoris*, 182, 185  
*Tritonia*, 207, 213  
     *arborescens*, 254  
     *clavigera*, 207  
     *exsulans*, 226, 228  
     *festiva*, 218  
     *gigantea*, 208, 211, 213, 241  
     *hombergii*, 207, 216  
     *plebria*, 207  
     *reticulata*, 218, 226, 241  
     *tetraquetra*, 208, 211  
     *triegi*, 207  
*Tritoniella*, 224  
     *belli*, 224  
     *sinuata*, 224  
*Tritoniopsilla*, 208, 218  
     *brucei*, 218  
     *tetraquetra*, 208  
(*Tritoniopsilla*), *Tritoniopsis*, 213  
*Tritoniopsis* (*Tritoniopsilla*), 213  
*tuberculata*, *Archidoris*, 182  
     *Doris*, 182  
*Tylodina*, **56**, 61, 62, 66, 67, 68  
     *cervina*, 63, 64  
     *citrina*, 62, 65, 67, 68  
     *fungina*, **56**, 67, 68; pls. 5, 6, 11, 12, 16  
     *punctulata*, 56  
*Tylodinella*, 61, 66, 68  
     *trinchessii*, 65, 67
- Ulva*, 53, 54  
*Umbraculidae*, 56  
*Umbrella*, 61, 64  
*Umbraculum*, 61, 67  
*uncinata*, *Doto*, 243, 245



- Hancockia, 244, 245  
undulata, Pleurophyllidia, 197, 198  
    Sphaerostoma, 218, 225, 241  
universitatis, Chromodoris, 158, 163  
  
vancouverensis, Armina, 206  
    Pleurophyllidia, 205  
**varians**, Doto, 288, **289**, 294; pls. 42, 44, 48  
Velella, 355  
velox, Drepania, 127  
    Thecacera, 127, 129  
    Trapania, **127**, 129; pls. 20, 32  
**venustus**, Dendronotus, 255, **271**, 272, 279; pls.  
    40, 46, 47, 49, 50, 52  
  
Verongia thiona, 61  
verrucosa, Doris (Staurodoris), 177  
villosa, Membranipora, 132  
violacea, ?Austrodoris, 173  
**virens**, Cratena, **344**; pls. 61, 68, 70  
viridis, Govia, 244, 245  
    Hancockia, 248, 249  
  
Zephyrinidae, 302  
zetlandica, Aldisa, 170  
Zostera, 16, 20, 21  
    marina, 132















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